IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

IMPORTANT DATES

November 5

40th Anniversary Meetings of A.S.M.E.

November 18–19

First Meeting of Council of Federated American Engineering Societies

December 7–10

Annual Meeting of A.S.M.E.

Annual Meeting Program and First Instalment of Papers Appear in this Number

NOVEMBER 1920

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Mechanical Engineering

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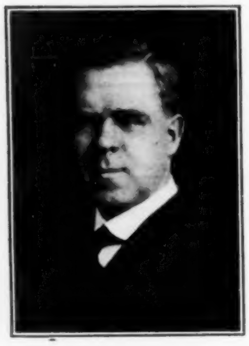
Contributors and Contributions

Valuable Group of Research Papers

The important investigation reported in the paper entitled Constitution and Properties of Boiler Tubes was carried out because of defects which developed in tubes of the boilers of the Park Place plant of the Detroit Edison Company, requiring replacement of the defective tubes, and consequently shutting down the boilers, not infrequently when a heavy load was on the plant. In consequence an extended investigation of the causes of the defects and possible remedies was carried out by A. E. White, Consulting Metallurgist of the Detroit Edison Company and Professor of Chemical Engineering at the University of Michigan. Professor White's conclusions are of unusual interest to all engineers in the power-plant field.



A. E. White

Prof. W. L. DeBaufre, now at the University of Nebraska, and the author of the paper on the Calibration of Nozzles for Measuring Air Flowing into a Vacuum, was for a number of years one of the leading research engineers of the U. S. Naval Engineering Experiment Station at Annapolis, Md., While at the Experiment Station, he directed a long series of tests upon air pumps and condensers, during which it was desired to measure quantities of air by means of nozzles. This led to a separate investigation, which is reported in this paper.

In making service tests on bearings used in supporting worms in motor-truck rear axles, Kalman Heindlhofer gathered important information about the efficiencies of worm drives. Mr. Heindlhofer, for the past two years Research Engineer for the SKF Industries, Inc., has in this issue, presented this material under the heading, Tests on Rear-Axle Worm Drives for Trucks.

Effects of Fittings on Flow of Fluids through Pipe Lines is a paper containing data of great value in designing pipe lines. Dean E. Foster of Tulsa, Okla., the author of the paper, is a consulting engineer in the oil fields. In the absence of readily available data, Mr. Foster made a careful study of the known facts about pipe fittings, and the present paper, which is the result of his study, supplies tables and curves for the ready use of the engineer.

D. E. Foster

The results of a rather unusual and extensive investigation of the Heat-Insulating Valve of Cork and Lith Board are given by A. A. Potter, J. P. Calderwood, A. J. Mack and I. S. Hobbs. A. A. Potter is at present head of the department of Mechanical Engineering at Purdue University, but when the paper was prepared, was Dean of Engineering at Kansas State Agricultural College, where his co-authors are at present members of the faculty.

Experiences with Large Center-Crank Shafts

A painstaking investigation necessitated by the failure of a center-crank shaft for a large gas engine, is recorded by Louis Illmer in this issue. The stress diagrams and analysis of the effect of wear on the bearings will be of fundamental value to the designer of large machine parts.

Principles of the Gyro-Compass

The disturbing forces acting on the gyro-compass when on shipboard are discussed in a paper by George B. Crouse, at one time an engineer of the Sperry Gyroscope Co. Mr. Crouse explains the principle of the gyro-compass and considers the major design problems, namely, compensation of disturbing forces, methods of suspension, and methods of damping.

Standardization

The fields open to standardization and the possibilities resulting from it seem unlimited. In fact, advance in engineering depends upon it. With emphasis, therefore, attention is called to the matter in this issue relating to standardization progress. Space will be devoted each month to this important work of the various standardizing bodies.

Superpower

The word Superpower has caught the imaginations of engineers. The progress on the Superpower Survey and the preliminary steps leading to it are discussed editorially in this issue, from information furnished by W. S. Murray who is in charge of this important work.

Books for the Engineer

A new feature in this issue is the book review contributed by Director Craver of the Engineering Societies Library. The engineer must read, but to read all technical works in his field is impossible. Mr. Craver's column will be of great assistance in choosing the most helpful books.

1920 A.S.M.E. MEETING LOOMS LARGE

The Engineering Societies Building, New York, will be the scene of four days of interesting events December 7–10.

Tentative program will be found on page 647 of Section One of this issue.

40th ANNIVERSARY MEETINGS

Plans for big celebration on November 5 are explained in Section Two of Mechanical Engineering. Section Two also contains complete accounts of A.S.M.E. Affairs.

MECHANICAL ENGINEERING

Volume 42 November 1920 Number 11

The Constitution and Properties of Boiler Tubes

Causes Underlying Defective Tubes—Grain Growth under Temperatures below Critical Point a Factor—Higher Carbon Content Suggested

By ALBERT E. WHITE,[1] ANN ARBOR, MICH.

During the winters of 1913–1914 and 1914–1915 considerable difficulty was experienced by the Park Place Heating Plant of The Detroit Edison Company in maintaining continuity of boiler operation. This difficulty arose because of the frequent shutdowns necessitated when boiler tubes bore evidence of being or becoming defective, requiring in consequence the temporary closing down of the boiler or boilers until the tubes in question could be replaced. Tubes in the front bank of the boilers were particularly prone to develop defects, and since this condition was experienced in its most aggravating form at a time when the boilers were most needed, namely, during the various cold snaps of the winter, investigations were started so that suitable steps might be taken to combat the trouble.

The necessity for obtaining relief was emphasized in June 1915, when No. 7 tube in the third row of No. 7 boiler at the Park Place Heating Plant let go. The appearance of this tube after the accident is given in Fig. 1. This tube failure made necessary the rebuilding of most of the boiler, and especially the replacement of nearly all of the tubes in the boiler. Fortunately no injuries were sustained by any of the men in the plant. Also, the failure occurred at a time of the year when the plant was not operating at full load, so that the customers were not subjected to any inconvenience through lack of steam.

The accident, however, indicated the need for prompt relief and investigations were started along three lines: (*a*) water softening, (*b*) rearrangement of baffling, and (*c*) considerations relating to the composition and constitution of boiler tubes.

Water Softening

With reference to water softening, it was noted that practically all of the tubes which were replaced showed a thin but tough scale on the water side. This scale was calcium sulphate and was thin simply because the quantity of this salt in the boiler feedwater was relatively small and in plants operating under normal load conditions would have warranted no consideration. In these boilers, however, which were of the Stirling water-tube type of 750 hp., the long periods of cold often necessitated a load averaging 80 per cent above the nominal rating for periods extending at times into as many as six days. These load conditions, while not apparently unusually exacting, were in reality very severe when cognizance is taken of the fact that 98 per cent of the boiler feedwater was raw water drawn from the city mains.

There was no question but that the thin scale seriously affected heat transmission and was one of the contributing factors leading to tube failure. Much research work was done on this phase of the problem and it resulted in a decision to treat all of the water in the plant with soda ash. Since this treatment has been in use practically all of the insolubles are caught in the live-steam purifier. There is no scale in any of the tubes, although there are flocculent particles of insoluble sodium carbonate circulating with the water in the boilers. This product, together with the other minor insoluble ones that may be present and the soluble salts, especially sodium sulphate, are kept down to harmless percentages by frequent boiler blow-offs. The Dionic tester is used as a guide, experience indicating that when it reads under 1800 no fear need be had of trouble resulting from foaming and priming.

Changes in Baffling

Steps were also instituted with reference to a study of the baffling. At the time when the trouble was most pronounced, the front baffles were between the first and second rows of tubes. This arrangement had been adopted since it was believed that it would produce higher temperatures with consequent fuel economy and abatement of the smoke nuisance.

The investigations showed that most of the tube replacements were from the front row. For the purpose, therefore, of distributing the radiant heat among a greater number of tubes, hoping in this way to increase tube life without, however, carrying the same to such an extent as to decrease the fuel economy or run into the smoke troubles coming from incomplete combustion, the front baffling was changed so as to lie between the second and third rows rather than between the first and second rows. This arrangement has been most beneficial. There has been no decrease in fuel economy nor increase in smoke nuisance and tube replacements have been materially lowered.

Fig. 1 Burst Tube from No. 7 Boiler, Park Place Heating Plant, Detroit Edison Company

[1] Consulting Metallurgical Engineer, Professor of Chemical Engineering, University of Michigan.

Abstract of paper to be presented at the Annual Meeting, New York, December 1920, of The American Society of Mechanical Engineers. All papers are subject to revision.

Constitution of Tubes

Under the third line of investigation listed above—the composition and constitution of boiler tubes—the first step was a study of the constitution of the metal in the tubes. This was undertaken for the purpose of ascertaining the effect of service conditions upon the types of tubes now employed. The metal in a very considerable number of tubes was examined metallographically, the

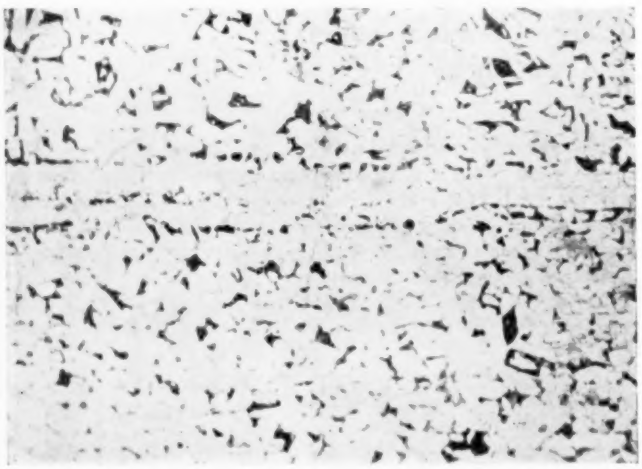


Fig. 2 Average Boiler-Tube Structure; Magnification 100; Etched with Nitric Acid

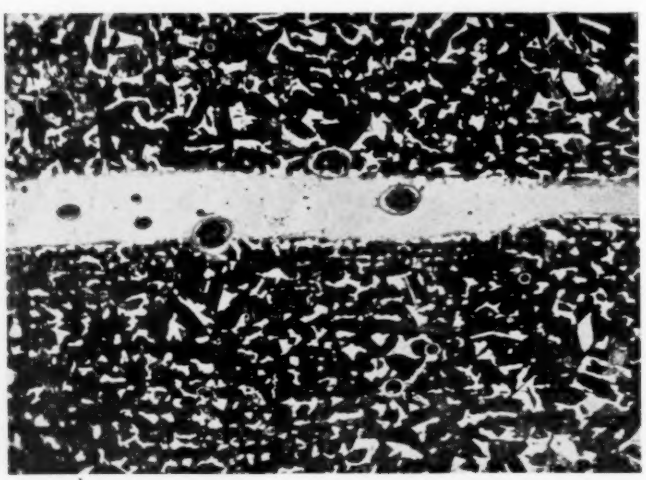


Fig. 3 Average Boiler-Tube Structure; Magnification 100; Rosehain-Etched

etching mediums being the common nitric acid and the so-called Rosenhain. This latter deposits copper over the surface of the metal, giving an even coating when the distribution of the metalloids is uniform; but when such is not the case, disclosing minutest segregations and imperfections most clearly by variations in the depth of the plating.

Two photomicrographs showing the structure of a piece of boiler-tube metal which was selected as typical of the average of the majority of the sections examined, are shown in Figs. 2 and 3. The photomicrograph in Fig. 2 was taken after a sample had been etched in nitric acid, and in Fig. 3 treated with the Rosenhain reagent. It will be noted that the etching is uniformly distributed, indicating that the constituents are evenly dispersed throughout the metal. A clearly defined ghost line is brought out, resulting from phosphorus segregation, although more apparent in one resulting from the Rosenhain etching. There are also strikingly evident cavities or segregations which the writer has detected in many of the samples which he has examined. He considers this condition most serious and will further discuss it below. [In the pamphlet copy of the paper are other photomicrographs of samples representing the average of the best structure and of the poorest structure found among the different specimens.—Editor.]

Causes of Tube Failure

On the completion of this preliminary survey attention was directed to the causes of tube failure. Excluding that due to imperfect heat transmission resulting from scale, the writer believes that the principal causes can be listed under the following heads:

a Failure due to tube brittleness resulting from absorption by the metal of hydrogen and usually attributable to faulty boiler-feedwater treatment

b Failure due to blowholes or other imperfections in the metal

c Failure due to recrystallization of the metal.

Tube Brittleness Resulting from Hydrogen Absorption. The first of these causes, namely, that due to tube brittleness resulting from the absorption by the metal of hydrogen, will not be developed in this paper. The facts are outstanding that contained hydrogen in metal makes it extremely brittle. The facts are further outstanding that certain types of water improperly treated, or all water excessively treated with certain types of boiler compounds, will cause the tubes to absorb hydrogen and become brittle. With intelligent treatment, however, there need be no cause for concern over tube failure from this source.

Failure from Blowholes. Failure from blowholes and other imperfections, the writer believes, should receive greater consideration in the future than has been accorded it in the past. The matter of course goes back to the steel mill and calls for greater emphasis on quality and less on tonnage.

A photomicrograph of a sample of metal containing blowholes is shown in Fig. 4. The ghost line is evident and even a casual scrutiny reveals radiating lines issuing from the center of the cavity. This condition is manifest in all of the photomicrographs taken of specimens with blowholes and indicates a lack of continuity of the metal. Should service conditions cause the tube to bag and should a cavity of the pipe shown in Fig. 2 be at the nipple of the bag, there is every reason to anticipate a bursting of the tube, with all of the attending dangers and expense.

Failure from Recrystallization. This matter merits much consideration. Recrystallization is accompanied by a marked decrease in the elastic limit and fatigue-resisting properties of the metal manifesting this phenomenon. It will occur if steel with a low carbon content which has previously been mechanically deformed at a temperature below the critical is later heated for a sufficient

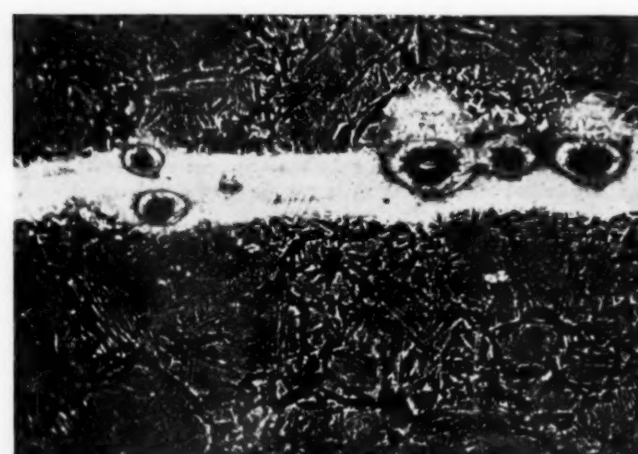


Fig. 4 Example of Blowhole, Prepared from Section of Boiler Tube; Magnification 100; Rosenhain-Etched

time to any temperature below that at the critical. The common composition for boiler tubes is such that this class of metal is especially susceptible to this phenomenon. Mechanical deformation to some degree is unfortunately assured by present-day methods of handling tubes, for at the mill tubes are straightened and in many cases actually brought to final size when below the critical temperature. Tubes are often bent during fabrication and erection and are universally rolled into the tube sheet when cold, and the methods of cleaning tubes in service often employ forms of apparatus which produce local deformation by repeated hammer

blows. Finally, the time and temperature conditions required for recrystallization are present.

Time-Temperature Criterion for Crystal Growth

Heating of deformed metal to temperatures approaching the critical, causes crystal growth in very short time periods. Corresponding growth occurs more slowly at lower temperatures, the time periods required for the same increasing very rapidly as the temperature to which the material is heated decreases. Values experimentally determined for temperatures from 550 deg. cent. (1022 deg. fahr.) to 675 deg. cent. (1247 deg. fahr.) for one set of conditions, are given by the following equations:

T (minutes) $= 8$ for 675 deg. cent. (1247 deg. fahr.)
T (minutes) $= 8 \times 3$ for 650 deg. cent. (1202 deg. fahr.)
T (minutes) $= 8 \times 3^2$ for 625 deg. cent. (1157 deg. fahr.)
T (minutes) $= 8 \times 3^3$ for 600 deg. cent. (1112 deg. fahr.)[1]

or, in general, for temperatures below 675 deg. cent. (1247 deg. fahr.)

$$T = 8 \times 3^n$$

where T = time in minutes
t = temperature in degrees centigrade
$n = (675 - t)/25$

That the normal method of handling boiler tubes results in mechanical deformation and that this metal as a result, under the proper conditions of time and temperature, will develop large crystals, is shown in Figs. 5 and 6. Fig. 5. is from a photomicrograph of a specimen of a tube which has been so deformed, and Fig. 6 from a specimen after receiving heat treatment at a temperature below the critical which quickly developed grain growth. A comparison of the grain sizes of the two samples indicates that the tube has been sufficiently deformed to respond to the laws of grain growth when the proper conditions for this development are present.

Physical Tests

Both tension tests and fatigue tests were made to determine the effect of coarse grains on the physical properties of the tubes. In each of the tension tests three samples per set were employed: the first on metal as received, the second on metal annealed for 10 minutes at 950 deg. cent. or 1742 deg. fahr. and then cooled in the furnace and the third on coarse-grained metal produced by stressing all of the test specimens the same amount and in all cases past the elastic limit and followed by an annealing for three hours at a temperature of 800 deg. cent. or 1472 deg. fahr. In the fatigue tests ten samples per set were used because of the greater difficulties in a test of this kind in securing check results.

The physical properties of the "as received" samples showed satisfactory metal. The average tensile-strength and elastic-limit values of the "coarse-grain" samples" were 27.2 and 58.9 per cent lower than they were for the "as received" samples and indicate, therefore, a decidedly inferior grade of metal. In the fatigue tests, also, the "coarse-grain" metal was 16.2 per cent poorer than the "as received," and 48.70 per cent poorer than the "annealed" metal.

Composition of Tubes

In view of all of the conditions above pointedout there arose a question as to whether or not the present composition of boiler tubes, from the consumer's standpoint, was the most acceptable. Would there be a composition as easy to make from the producer's viewpoint, as easy to install, as resistant to the absorption of hydrogen, more strong, as free, if not freer, from blowholes, and above all less subject to recrystallization?

This is a formidable set of conditions, and yet do not tubes with a carbon content between 0.30 to 0.35 per cent more perfectly meet all of the above conditions than tubes with a carbon content ranging between 0.08 to 0.18 per cent?

Tubes with this higher carbon range will not be appreciably more difficult to manufacture or to install and there is nothing to indicate that they will absorb hydrogen more readily. It should be possible to make them as free of blowholes; there is no question but that they are at least 40 per cent stronger as measured by tensile-strength and elastic-limit tests throughout all working temperatures with no detrimental decrease in elongation or reduction; and finally, and most important of all, tubes with the higher carbon range are not subject to recrystallization.

Figs. 5 and 6 Effect of Heat Treatment on the Grain Size of Boiler Tubes; Sections Adjacent to Tube Sheet; Etched in Nitric Acid; Magnification 100; Fig. 5, Untreated; Fig. 6, Heated at 650 Deg. Cent. for 15 Hours

On this last point the literature is suggestive, although there have been no pieces of work as yet published as far as the writer knows which give direct proof.

In view of this condition, therefore, the following test was carried out to ascertain roughly the carbon range in which grain growth on deformed iron[1] when heated at temperatures below the critical range, occurred. Five irons were used with carbon varying from 0.006 to 0.315 per cent. Each of the samples was annealed so as to secure freedom from strains and obtain minimum grain size. This treatment was then followed by impressing a 5-mm. ball on each specimen under a load of 3000 kg. Each sample was then heated for four hours at 675 deg. cent. or 1247 deg. fahr., a temperature considerably below the critical for all of the carbon ranges present. The specimens were then examined and the average grain size in the section undeformed and in that portion of the deformed area showing maximum grain size compared.

The results given in Table 1 and shown in Fig. 7 indicate that iron in carbon ranges from 0.006 to 0.251 per cent, inclusive, undergoes a perceptible grain growth when treated as just described and that iron with a carbon content of 0.315 per cent is

[1] Recrystallization as a Factor in the Failure of Boiler Tubes, White and Wood. Proc. American Society for Testing Materials, vol. xvi, pp. 82–116.

[1] The word "iron" is used in its generic sense and is intended to include steel and what is commonly called ingot iron.

(Continued on page 618)

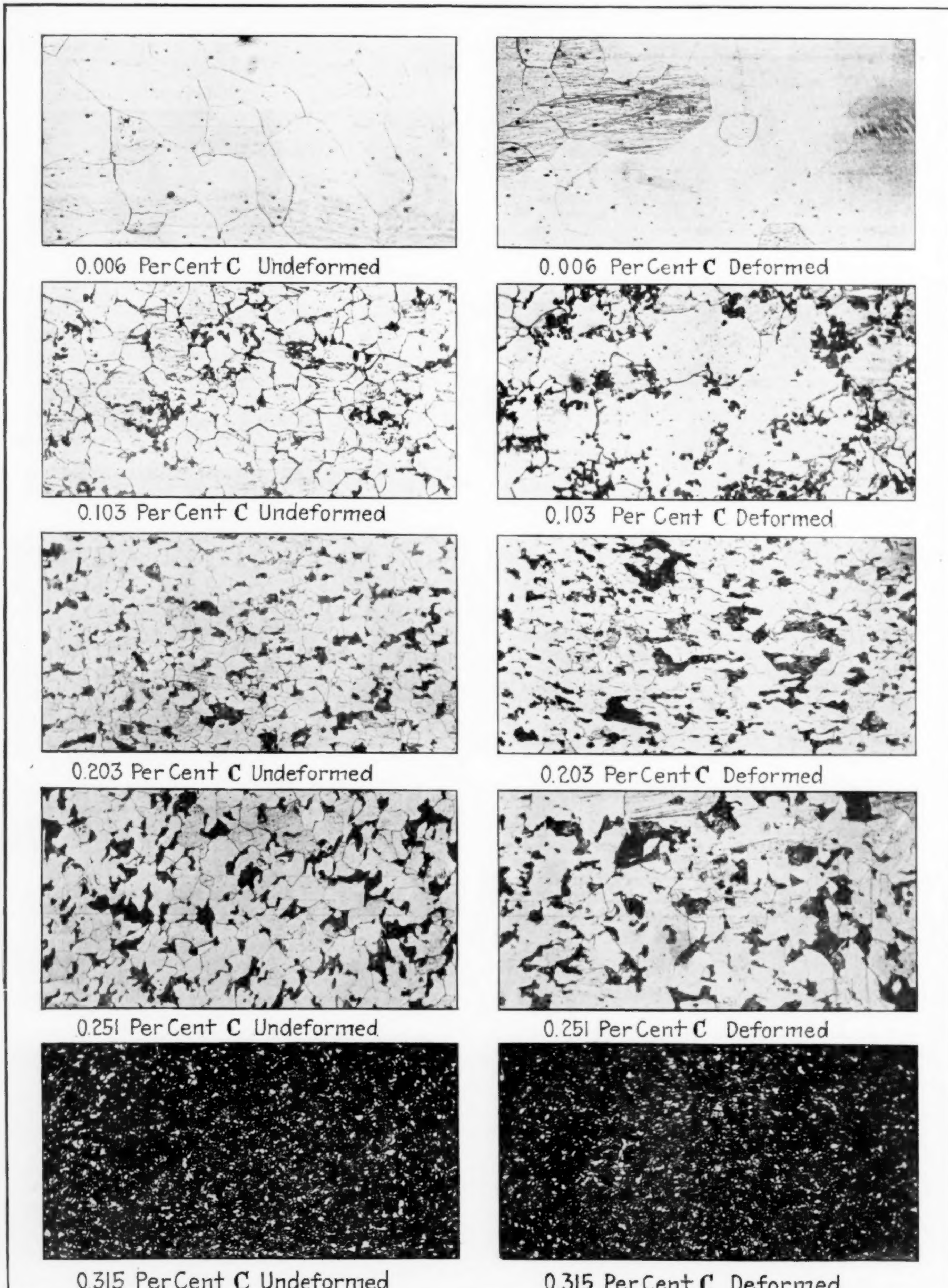


Fig. 7 Effect of Carbon Content on Grain Growth in Deformed Iron When Heated Below Critical Temperature; Magnification 100; Etched in Nitric Acid. (Accompanying Article on Preceding Pages.)

Calibration of Nozzles for Measurement of Air Flowing into a Vacuum

By WM. L. DE BAUFRE,[1] LINCOLN, NEB.

The following paper is based upon an investigation of the flow of an elastic fluid through nozzles having well-rounded entrances, the effects of frictional resistance and of moisture in the atmosphere when the fluid is atmospheric air being taken into account. It is shown that the rate of flow of dry air decreases with increases of moisture, this result being based upon a series of tests on metal nozzles. The paper includes a description of the nozzles, the method of calibrating them, and the results obtained. Formulae employed in the calculations are also derived and the theory involved is outlined.

During some tests of air pumps, condensers, etc., conducted at the U. S. Naval Engineering Experiment Station, Annapolis, Md., it was desired to measure quantities of air by means of nozzles, the air flowing from the atmosphere through the nozzle into a vacuum. The problem was therefore to make a number of nozzles having orifices of suitable areas and to calibrate them, rather than to investigate correction factors for nozzles of different shapes. The following paper is based upon a report submitted on this work, and includes not only a description of the nozzles constructed, the method of calibration and the results obtained, but also the formulæ and calculations to be used. The complete paper from which this was abstracted contains a development of the formulæ and the theory involved.

Description of the Nozzles

Twenty monel-metal nozzle plugs were made of the general shape shown in Fig. 1-A. Monel metal was selected as it is practically non-corrodible and takes a high polish. The plugs were threaded with a 1-in. pipe thread, a standard ring thread gage being used to secure interchangeability. It was intended to use these plugs in a soft brass bushing as shown in Fig. 1-B in order to preserve the threads as long as possible. The threaded joint between plug and bushing was made tight with asphaltum.

Each plug was $1^1/_4$ in. long, and the 1-in. pipe thread permitted the use of a maximum diameter of 1 in. for the orifice through the plug. An entrance curve to the orifice was selected as shown in Fig. 1-C, constructed of two arcs approximating an ellipse. This entrance curve takes up three-tenths of the length of the nozzle, leaving in the case of the 1-in. orifice a straight portion seven-tenths of the nozzle length. The cross-section of all nozzles having orifices less than 1 in. in diameter are made geometrically similar to the 1-in. nozzle by counterboring the plug. In all nozzles, therefore, the length of the straight portion is seven-eighths its diameter, and the length of the entrance portion is three-eighths its diameter.

The diameters of the orifices were selected to correspond to standard drill sizes and to give convenient increments in area as given in Table 1. Except for the sizes below $^1/_4$ in., they were drilled $^1/_{32}$ in. smaller in diameter and reamed to size. The entrance surface was rubbed down with emery cloth to templet, giving the nozzle a highly polished appearance.

[Editor's Note: At this point in the complete paper the author discusses the theory of air flow through nozzles. He first develops equations for frictionless flow when no heat is imparted to or received from the flowing fluid by the nozzle. He next develops equations for flow which is not frictionless and shows that the coefficient of resistance depends upon the diameter and length of the nozzle, and for a given nozzle is therefore constant. He also shows that with a constant coefficient of resistance in the relation

$$p_1 v_1^n = p v_a^n$$

the exponent n can be taken as a constant and should evidently be the same for geometrically similar nozzles. The efficiency N of the nozzle he defines as the ratio of the kinetic energy actually possessed by the flowing mass to that theoretically available by adiabatic expansion through the same pressure range. The efficiency is therefore, dependent upon the ratio of expansion p/p_1 as well as upon the exponent of the expansion n. Equations are developed for calculating rates of flow for all possible values of the expansion ratio p/p_1. These equations take the form

$$\frac{G}{F} = \psi \sqrt{p_1 d_1}$$

in which G = rate of flow; F = area of orifice in sq. ft.; ψ = weight-flow factor; p_1 = initial pressure; and d_1 = initial density. The author also presents additional formulæ and curves for the calculation of the various terms.]

Description of Apparatus Used

The nozzle to be calibrated was screwed into a brass bushing mounted at N (see Fig. 2) in the side of the sheet-steel tank A. This tank was 8 ft. in diameter and 16 ft. high. A special cover or valve was arranged to close the nozzle. This valve, shown in open position in Fig. 3, consisted of a rubber-covered plate mounted

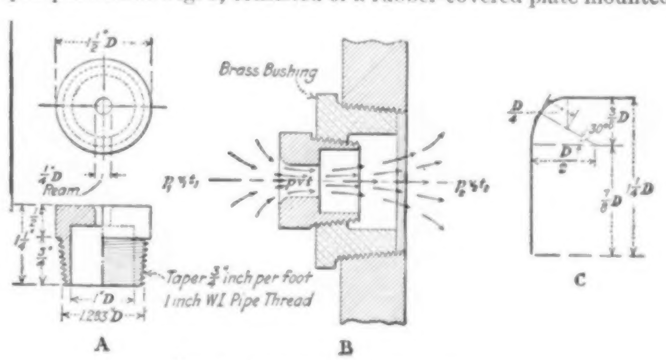


Fig. 1 Details of Nozzle Plugs

A, Cross-section of Nozzle; B, Method of Inserting Nozzle in Tank; C, Construction of Entrance Curve

on trunnions in a flat bar hinged at one end to the tank and having a handle at the other end. With the nozzle plug in place, the two screws at the back of the valve were adjusted so that its rubber-

TABLE 1 NOZZLE SIZES AND CAPACITIES

Nozzle Number	Drill Size	Diam. by Measurement, In.	Capacity, Lb. per Hr.	Capacity, Cu. Ft. per Min.
1	No. 46	0.08537	6.79	1.51
2	No. 33	0.11239	11.77	2.62
3	No. 21	0.15683	22.93	5.10
4	No. 9	0.19653	36.01	8.01
5	No. 1	0.22671	47.92	10.70
6	1/4 in.	0.24944	58.00	12.90
7	9/32 in.	0.27721	71.63	15.90
8	5/16 in.	0.31527	92.65	20.60
9	11/32 in.	0.34385	110.20	24.50
10	3/8 in.	0.37490	131.00	29.10
11	13/32 in.	0.40600	153.70	34.20
12	7/16 in.	0.43822	179.00	39.80
13	15/32 in.	0.46755	203.80	45.30
14	1/2 in.	0.49895	232.10	51.60
15	9/16 in.	0.56823	301.00	67.00
16	5/8 in.	0.61981	358.10	79.70
17	11/16 in.	0.68735	403.90	89.90
18	3/4 in.	0.74950	523.70	116.50
19	7/8 in.	0.87595	715.20	159.10
20	1 in.	0.99885	930.00	206.90

Note.—Capacity based on dry air at 70 deg. fahr. and with an initial pressure of 29.92 in. mercury and a final pressure less than 15 in. mercury.

covered face fitted evenly over the face of the plug. The valve was held tightly closed by a hand nut screwed on a stud in the tank.

The atmospheric pressure was indicated by a mercury barometer hung on a nearby wall, and the vacuum within the tank was measured by a mercury gage M (see Fig. 2). The latter was of the floating-scale type, consisting of a cast-iron float with a brass scale attached thereto. The float rises or falls with the mercury in the cistern so that the zero of the scale always corresponds with

[1] Chairman M. E. Dept., Univ. of Neb., Mem.Am.Soc.M.E.

For presentation at the Annual Meeting, New York, December 7 to 10, 1920, of The American Society of Mechanical Engineers. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

the surface of the mercury. The difference between atmospheric pressure and the absolute pressure in the tank was therefore obtained by a single reading—the height of the upper end of the column of mercury in the gage glass, obtained by means of a sliding index. Only one side of the column was used, it being of the duplex type. A thermometer was hung on the column to obtain its temperature.

The temperature within the tank was obtained from the resistance of a copper wire (No. 36 B. & S. Gage) strung from top to bottom of the tank six times and distributed across a diameter as shown at *W* in Fig. 4. This figure also shows diagrammatically the arrangement of the bridge used to measure the resistance of the wire *W*. The leads L_1 were of No. 12 copper wire, with compensating leads L_2 of the same size and length.

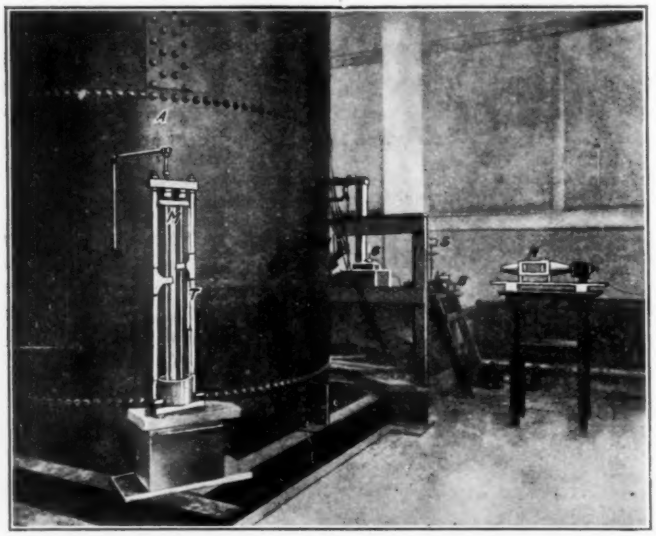


Fig. 2 Apparatus Used for Tests
A, Tank; M, Mercury Gage; N, Nozzle; H, Exhauster

The temperature and humidity of the atmospheric air flowing into the nozzle under calibration were determined from readings of dry- and wet-bulb thermometers placed in the suction duct of a small exhauster *H* (Fig. 2). The wet bulb was moistened by a cotton wick which dipped into one leg of a U-tube kept filled with water. By raising or lowering this U-tube, the cotton wick could be kept just sufficiently moist around the thermometer bulb, a drop of water occasionally falling from its lower end.

The evacuation of the tank was accomplished by a Westinghouse-Leblanc air ejector connected to the tank at *D* (Fig. 4). While the tank was being exhausted, valves *C* and *D* were open and valve *E* was closed. When the desired vacuum was attained, valves *C* and *D* were closed and valve *E* was opened to admit water from the vessel *F* to water-seal valve *D*.

Method of Conducting Tests

The nozzle to be calibrated was first mounted in place, the valve adjusted to cover the nozzle squarely and the hand nut screwed down to hold the valve tightly closed. The tank was then exhausted by the ejector to a vacuum of 28 to 29 in. of mercury and the intervening valves closed and water-sealed. The tank was then allowed to stand overnight in this exhausted condition in order to insure that a portion of the water previously put into the tank would have time to evaporate and saturate the interior space. It was found necessary to add water in order to replace the moisture withdrawn with the air by the ejector; and if sufficient time were not allowed for the water to evaporate, the vapor pressure taken from steam tables to correspond to the temperature within the tank would be greater than the actual existing pressure, thus indicating that the space was not saturated with water vapor.

In order to obtain some idea of the weight of water required to be put into the tank, a curve was derived to give the actual volume of air removed at a continuously decreasing pressure according to the relation

$$\frac{v_r}{v_1} = \log_e \frac{p_1}{p_2} \quad \text{. . . . .} \quad [1]$$

in which v_r = total volume of air removed
v_1 = volume of tank
p_1 = initial pressure in tank
p_2 = final pressure in tank.

The application of this formula may be shown by an example. Thus, if the tank is exhausted from an atmospheric pressure of 30 in. mercury to a vacuum of 29 in. mercury, we shall have

$$\frac{p}{p_1} = \frac{30}{30 - 29} = 30$$

and from the formula or curve

$$\frac{v_r}{v_1} = 3.41.$$

The volume of the tank as determined by calibration with water was about 865 cu. ft. Hence

$$v_r = 3.41 \times 865 = 2950 \text{ cu. ft.}$$

This will also be the volume of the water vapor removed; and assuming it to be saturated steam at a temperature of 70 deg. fahr., with a corresponding density of 0.001148 lb. per cu. ft. (taken from steam tables), we find 3.4 lb. are withdrawn. Accordingly, about 5 lb. of water was put in the tank before exhausting each time.

Allowing the exhausted tank to stand overnight did not always insure saturation, and before taking readings the nozzle was opened to admit atmospheric air until the absolute pressure within tank doubled; that is, the vacuum dropped from say 29 to 28 in. mercury. The moisture brought in from the atmosphere together with the vapor in the tank insured saturation.

Each calibration run, during which the air nozzle under calibration was open, was preceded and followed by a leakage period. During the initial leakage period, readings of the barometric pressure, the vacuum within the tank, and the temperature within the tank were taken at intervals of 3 min. for a duration of 30 min. Then the nozzle was quickly opened at a given second to start the run and readings of the barometer, mercury column and wet- and dry-bulb thermometers taken at intervals of 30 sec. The run was ended by quickly closing the nozzle a certain number of

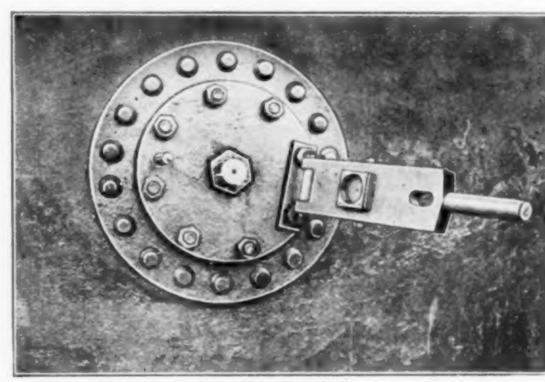


Fig. 3 Special Valve for Closing Nozzle

TABLE 2 SUMMARY OF RESULTS

Nozzle Number	Nozzle Diam. In.	Number of Runs	Average Weight-Flow Factor	Average Expansion Exponent	Average Weight-Flow Efficiency Per cent
1	0.08537	9	3.646	1.349	93.86
2	0.11239	6	3.786	1.378	97.48
3	0.15683	12	3.770	1.375	97.08
4	0.19653	4	3.824	1.387	98.46
5	0.22671	5	3.853	1.393	99.20
6	0.24944	2	3.768	1.375	97.02
7	0.27721	4	3.834	1.389	98.72
8	0.31527	2	3.748	1.370	96.49
9	0.34385	4	3.791	1.380	97.61
10	0.37490	2	3.776	1.376	97.22
11	0.40600	2	3.779	1.377	97.28
12	0.43822	4	3.767	1.374	96.98
13	0.46755	2	3.774	1.376	97.16
14	0.49895	2	3.781	1.377	97.35
15	0.56823	2	3.759	1.373	96.77
16	0.61961	2	3.831	1.388	98.64
17	0.68735	2	3.791	1.379	97.61
18	0.74950	1	3.636	1.346	93.61
19	0.87595	1	3.790	1.379	97.58
20	0.99885	1	3.728	1.366	95.98

minutes after opening it, the length of the run depending upon the size of the nozzle. A short run was necessary with the larger nozzles in order to prevent the pressure within the tank rising above the critical value. The final leakage period began at the time the nozzle was closed and continued for 30 min.

TABLE 3 VALUES OF WEIGHT-FLOW FACTOR FOR VARIOUS UNITS

Weight Flow G	Orifice Area F	Initial Pressure p	Initial Density d	Numerical Value of Factor ψ
lb. per sec.	sq. ft.	lb. per sq. ft.	lb. per cu. ft.	3.771
lb. per sec.	sq. in.	lb. per sq. in.	lb. per cu. ft.	0.3143
lb. per sec.	sq. in.	inches mercury	lb. per cu. ft.	0.2203
lb. per hr.	sq. ft.	lb. per sq. ft.	lb. per cu. ft.	13,576
lb. per hr.	sq. in.	lb. per sq. in.	lb. per cu. ft.	1,131.3
lb. per hr.	sq. in.	inches mercury	lb. per cu. ft.	792.9
kg. per hr.	sq. cm.	mm. mercury	kg. per cu. m.	11.061

TABLE 4 VALUES OF WEIGHT-FLOW FACTOR FOR VARIOUS UNITS

Weight Flow G	Orifice Area F	Initial Pressure p	Initial Temperature t	Numerical Value of Factor ψ
lb. per sec.	sq. ft.	lb. per sq. ft.	deg. fahr.	3.771
lb. per sec.	sq. in.	lb. per sq. in.	deg. fahr.	3.771
lb. per sec.	sq. in.	inches mercury	deg. fahr.	1.852
lb. per hr.	sq. ft.	lb. per sq. ft.	deg. fahr.	13,576
lb. per hr.	sq. in.	lb. per sq. in.	deg. fahr.	13,576
lb. per hr.	sq. in.	inches mercury	deg. fahr.	6,668
kg. per hr.	sq. cm.	mm. mercury	deg. cent.	18.458

Calculation of Results

The details of the method employed in correcting the data and deducing the results are illustrated and explained in the Appendix of the complete paper for Run 1 of Nozzle 1. To obtain the dry-air density in the tank the temperature and pressure observations for the leakage intervals preceding and following each run were plotted as shown in Fig. 5 and the calculations based on the curves rather than directly upon the observations. A curve was also plotted of weight-flow factor ψ to expansion exponent n so as to enable item 25 being obtained from item 24, and in Table 2 there have been tabulated for each nozzle the average values of the weight-flow factor, the expansion exponent, and the weight-flow efficiency. The number of runs made on each nozzle is also given. It will be noted that the calculations were based upon the pressure and temperature within the tank before the nozzle was opened and after it was closed, when the conditions were static, rather than upon the pressure and temperature, while the air was flowing into the tank.

Assuming all the individual runs to be of equal weight in ap-

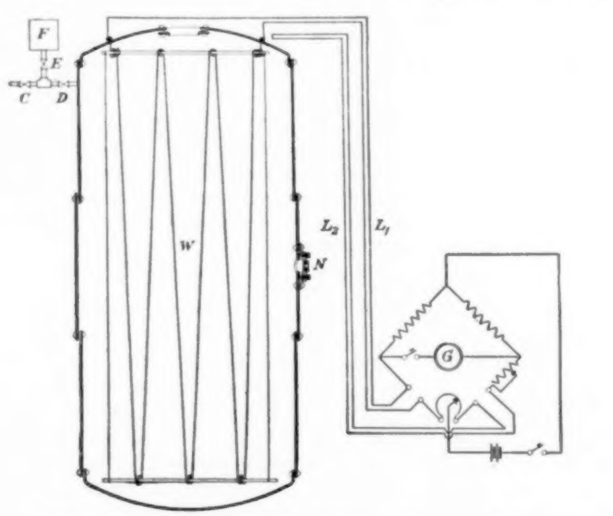


Fig. 4 Diagram Showing Method Employed to Measure Temperature within Tank

plying the formula for the probable error of the mean value, we obtain the expansion exponent $n = 1.3747 \pm 0.0013$, and assuming the average values in Table 2 for the several nozzles to be of equal weight, we obtain $n = 1.3753 \pm 0.0018$. The probable error for a single run and for a single nozzle are, respectively, ± 0.0107 and ± 0.0078. That is, for carefully made nozzles geometrically similar to those tested, the value of n will probably be within 0.010 of 1.375 if the observations are taken as carefully as during this calibration test. The corresponding value and accuracy of the weight-flow efficiency are 97.1 ± 1.2 per cent.

Corresponding to the expansion exponent $n = 1.375$, the numerical value of the weight-flow factor ψ in the formula

$$\frac{G}{F} = \psi\,\sqrt{pd}$$

will depend upon the units in which the several quantities G, F, p and d are expressed, as indicated in Table 3.

For final pressures greater than the critical pressure, that is, p/p_1 greater than 0.533, the factor will be reduced as given by the solid curve Fig. 6, for the units in the sixth line of Table 3.

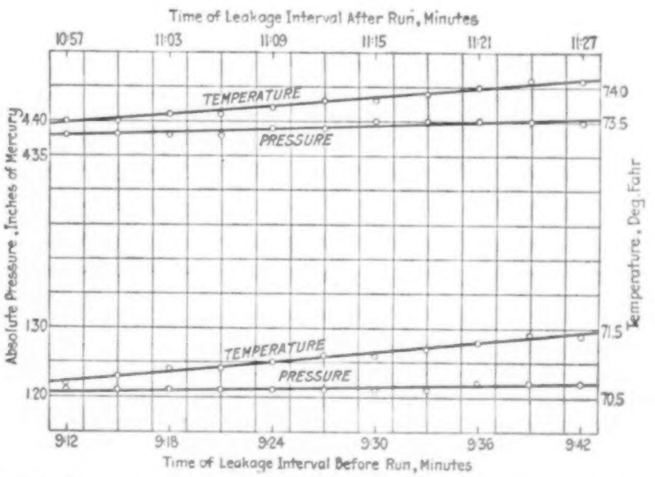


Fig. 5 Curves Showing Absolute Pressure and Temperature for Leakage Intervals Both Before and After Run No. 1 on Nozzle No. 1

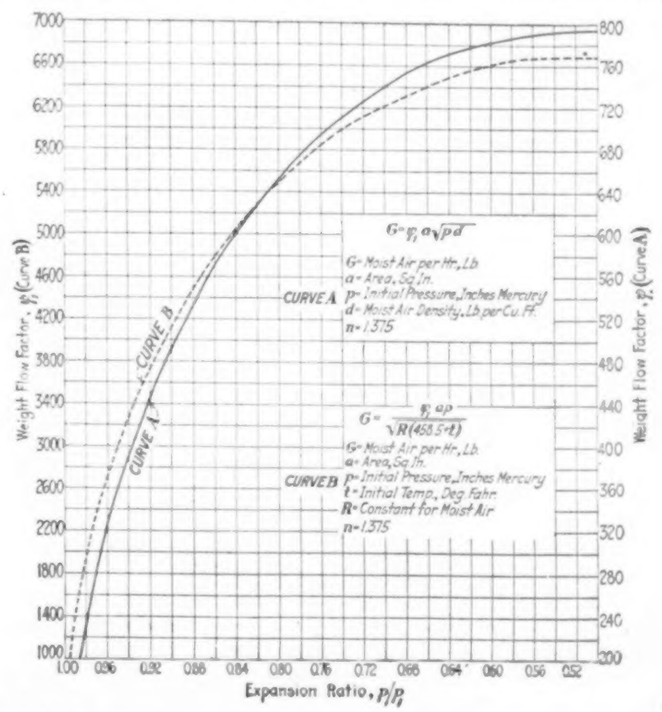


Fig. 6 Curves of Weight-Flow Factor with Expansion Ratio for $n = 1.375$

Changing the above formula into the form

$$\frac{G}{F} = \frac{\psi}{\sqrt{R}}\,\frac{p}{\sqrt{458.5 + t}}$$

also changes in certain cases the numerical value of ψ for the same units of G, F, p and t, as shown in Table 4.

For pressure ratios greater than 0.533, the dotted curve in Fig. 6 gives the reduced values of ψ corresponding to the units in the sixth line of Table 4.

The value of the constant R depends upon the ratio of water vapor to dry air in the fluid flowing through the nozzle and the

(Continued on page 650)

Experiences with Large Center-Crank Shafts

By LOUIS ILLMER,[1] PHILADELPHIA, PA.

This paper is descriptive of some disastrous experiences with a number of large gas-engine shafts of the center-crank type. The shafts were mounted upon three-point bearing supports and carried a heavy flywheel between the intermediate and outboard bearings. The stress diagrams show that this mode of support is likely to set up a pernicious interaction of bearing load, culminating in excessive wear in the intermediate main bearing.

When the wheel shaft lacks adequate stiffness, the appreciable lifting action at the free end of the web portion of a center-crank shaft may exert a considerable thrust against the cap of the aligned outer main bearing, which in turn reacts upon the intermediate journal, causing it to become overloaded. The resulting rapid wear in the intermediate main bearing reduces the upward cap thrust and this drop in alignment gradually relieves the intermediate bearing of overload. Further wear causes a portion of the downward load on the intermediate bearing to be transferred to the outer main bearing. It was found that when this readjustment is complete, the downward load upon the two main bearings becomes approximately equalized. The considerable sag required to attain this state of equilibrium as to wear, involved running under stress conditions so severe as to lead to ultimate breakdown of the wheel shaft.

In order to keep the wheel-shaft stress within desired limits under load conditions found in these engines, it finally became necessary to enlarge the intermediate main journal to $^3/_2$ of its original diameter, thus making its dimensions fully as large as required for side-crank construction. It was found to be expedient to make a careful analysis of the underlying stress conditions so as to insure a proper margin of safety in both the web and wheel parts after allowing for the lengthening of the span between the wheel supports due to excess wear in the intermediate main bearing.

SEVERAL years ago a series of disastrous center-crank shaft failures occurred in a 1200-kw. gas-power plant which the author investigated and in which he found that the wheel shafts were entirely too light for the load they had to carry.

The gas-power plant comprised three 25-in. by 43-in. 500-b.hp. double-acting producer-gas engine units, each driving a 400-kw. 25-cycle three-phase alternator at 100 r.p.m. The engines were of the direct-connected horizontal type, provided with a massive flywheel. The shafts were of the single-throw center-crank type, as indicated in Fig. 1, having a tensile strength of about 65,000 lb. per sq. in.

After being in 24-hour-a-day service for some four or five years, one of the shafts unexpectedly gave way near the flywheel hub, allowing the armature to drop and thus completely wreck its generator and heavy wheel, and in other ways doing serious damage.

In order that the cause of this and similar shaft failures might be intelligently arrived at, a series of sag determinations was conducted on the wheel shaft and a thorough technical investigation made of the underlying stress conditions.

The three-point shaft support for the heavy flywheel was found to set up a pernicious interaction of load which led to excessive wear in the intermediate main bearing. This resulted in the lengthening of the effective shaft span, which in turn produced sag stresses of such magnitude as to cause ultimate rupture of the shaft.

The inadequacy of a center-crank shaft for carrying a heavy wheel is made evident in the accompanying deflection diagrams. An excessive wheel-shaft deflection puts a large upward thrust against the outermost main bearing cap. The reaction of this thrust upon the intermediate main bearing may become so large as to squeeze the babbitt lining out of the bearing shell, in which event the resulting drop in this vital support allows the shaft to run with an excessive sag between the outermost main bearing and the outboard bearing. Thus the shaft stresses may be increased far beyond those usually anticipated by the engine builder, and if allowed to continue can readily cause the metal of this shaft to undergo such rapid fatigue as to lead to shaft rupture.

The matters of fixed stress limits and requisite factor of safety underlying good shaft design are rather fully discussed in the Appendix accompanying the complete paper.

Crankshaft Stress Diagrams

The shaft outline and load conditions under which the original shafts operated are shown in Fig. 1, in which the line A-A indicates the location of the wheel-shaft failure, its relative position being almost identical in three of these shafts. The journal portion of the shaft was carried straight up to the wheel hub but as indicated by the dotted outline in Fig. 1, it was entirely feasible to enlarge the shaft immediately after clearing the camshaft gear. Had this been done originally, it would have obviated the worst of the peak stresses shown in the diagram.

The original shafts were excessively loaded by a massive flywheel weighing about 73,000 lb., and by an armature of about 13,000 lb., to which should be added an assumed magnetic pull of about 10,000 lb., on the basis of $^1/_{32}$ in. armature displacement. The location of those weights is shown in Fig. 1, and their relative magnitude is indicated by varying line lengths, extending downward.

In making a preliminary stress analysis, in the conventional manner, it may be assumed that the wheel shaft is pin-supported between the intermediate main bearing I and the outboard bearing III. The resultant wheel-shaft load P_r = 96,000 lb., acting downward, causes the shaft to deflect, thus putting the bottom fibers in tension and the top fibers in compression. The rotation of the shaft sets up a reversal of stress with each revolution.

In addition to these alternating stresses, the shaft is subject to a negligible shear stress due principally to the weight of the wheel. In a horizontal engine the effect of the connecting-rod thrust in producing an increase in the wheel-shaft stress may be sufficiently allowed for by taking into account only the twisting stress resulting from the transmission of power to the generator.

The effect of this twisting action may best be combined with the bending moment as indicated in the stress curve in Fig. 1. It will be seen that while the original wheel-shaft strength lacks uniformity, the maximum stress estimated on this preliminary basis reaches a peak value of only about 10,000 lb. per sq. in. near the point of rupture.

Assuming the wheel to be perfectly balanced and the shaft to run true, the basic or net factor of safety for this shaft, as determined by the Appendix, appears to be equal to about 2.2, as against a minimum stipulated factor of three. It is evident that this minor difference is insufficient to account for the wheel-shaft failure, but the diagram does show that this conventional mode of checking center-crank wheel-shaft stresses cannot be relied upon to bring out the cause of rupture.

Effect of Three-Point Shaft Support

In order to arrive at the cause of the present shaft failure, it is necessary to take into account the interacting effect of the three-point shaft support. Assuming all the bearings to be in perfect alignment, it will then be found that the excessive wheel-shaft deflection produced by the massive flywheel, puts a 20,000-lb. upward thrust against the cap of the outermost main bearing II, which in turn reacts upon and so overloads the intermediate bearing as to squeeze out its babbitt. As indicated in Fig. 2, the drop in this vital support causes sag stresses to be set up that more than double the peak stress previously determined by the preliminary stress check represented in Fig. 1.

The estimated stress relations shown in Fig. 1 assume the original wheel shaft to be pin-supported between bearings I and III only, a condition that is approximated when the cap is removed from the outer main bearing II.

The cap thrust of 20,000 lb. reacts to effect an increase in the downward load of the intermediate bearing. With the cap II forced into place under conditions of perfect alignment, the resultant downward pressure in the main bearing I is approximately 400 lb. per sq. in., and if to this the downward centrifugal force is added, a maximum pressure of about 500 lb. per sq. in. of net pro-

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For presentation at the Annual Meeting, New York, December 7 to 10, 1920, of The American Society of Mechanical Engineers. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

jected area is reached. Such a heavy bearing pressure fails to distribute uniformly and the consequence of excessive loading is to load by lowering its alignment with respect to the end supports of the shaft.

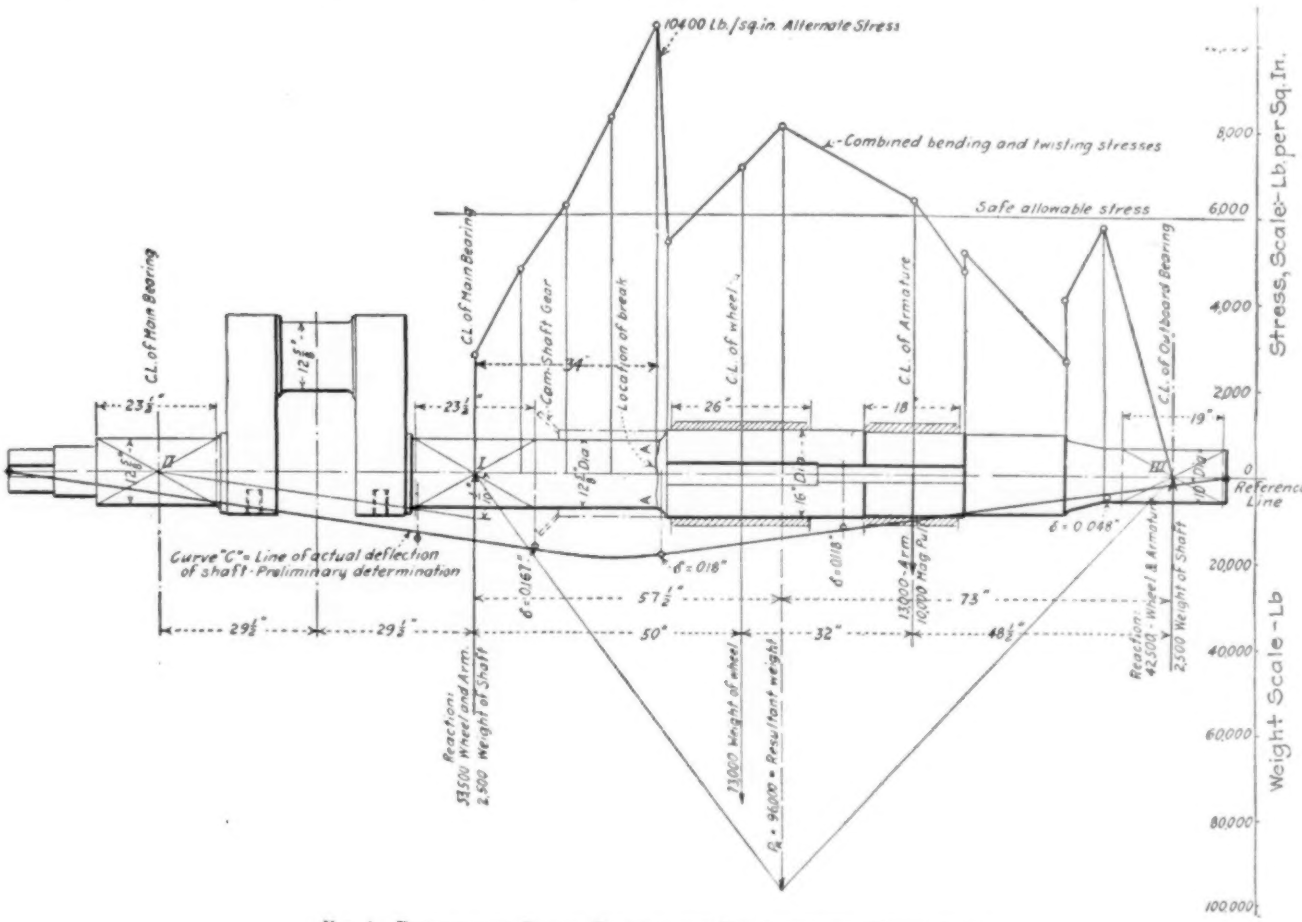

FIG. 1 PRELIMINARY STRESS DIAGRAM FOR PIN-SUPPORTED WHEEL SHAFT

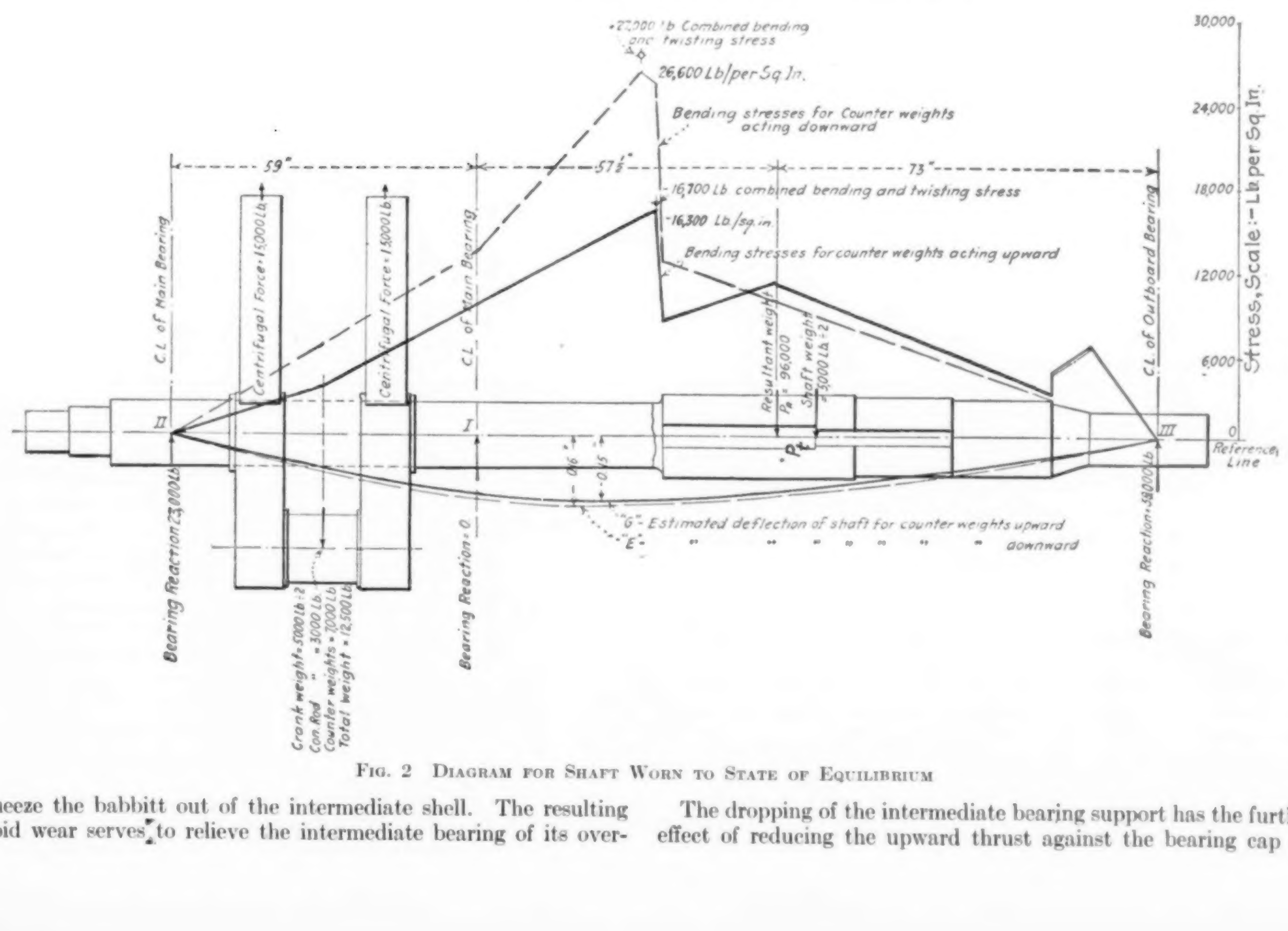

FIG. 2 DIAGRAM FOR SHAFT WORN TO STATE OF EQUILIBRIUM

squeeze the babbitt out of the intermediate shell. The resulting rapid wear serves to relieve the intermediate bearing of its overload by lowering its alignment with respect to the end supports...

The dropping of the intermediate bearing support has the further effect of reducing the upward thrust against the bearing cap II,

and as the downward forces undergo readjustment by continued wear, the outer main bearing II will gradually assume an increased portion of the downward shaft load. Experience shows that when the load upon each of the main bearings becomes approximately equal, a condition of stable equilibrium will have been established, after which the two main bearings continue to wear down together at a more or less uniform rate.

In order to attain such a state of equilibrium, the shafts must suffer undue deflection as indicated in Fig. 2. Experience further shows that when starting with newly aligned bearings this condition is reached in a remarkably short time, being approximately 30 days of continuous operation under the existing load conditions. The corresponding wear in the intermediate bearing was found to be about $^1/_8$ in. in this brief period, as against a normal wear of say $^1/_{64}$ in. to $^1/_{32}$ in. per year for continuous running.

Fig. 2 also shows the marked effect which the dropping of the intermediate bearing support has in enlarging the effective shaft span and thus largely increasing the bending stresses.

These high sag stresses have been checked by comparing the estimated deflection curve E with the actual wheel-shaft sag as taken off one of the original shafts. The deflections were determined by means of a pin gage and these measurements were corrected for the sag of the reference cord. Thus the actual shaft sag, measured at the center of the intermediate main bearing, was

Fig. 3 Fracture of Wheel Shaft

found to be about 0.16 in. lower than the end supports, as against an estimated value of about 0.14 in.

The calculations show further that after reaching the aforesaid state of equilibrium, the estimated maximum pressure acting in the main intermediate bearing is reduced to about 218 lb. per sq. in. of projected area, which can readily be sustained without excessive wear. Under these conditions the shaft suffers a maximum bending stress of about 26,600 lb. per sq. in., and it is found that this peak practically coincides with the point of rupture. This extremely high stress is still further increased when combined with the crank twisting stress.

Detrimental Effect of Heavy Counterweights

The massive counterweights with which these engines were provided were designed to balance the inertia effects of the heavy reciprocating parts, averaging about 115 lb. per sq. in. of piston area. When the centrifugal force acts upward, a maximum bending stress of 16,300 lb. per sq. in. results, while for downward action the bending stress is increased to about 26,600 lb. per sq. in. Combining these high stresses with the maximum twisting stress without allowing for shock or preignition, an equivalent maximum tension stress of 27,000 lb. per sq. in. is produced in the outer shaft fiber, and when this same fiber turns through 180 deg., it is subjected to a compressive stress of about 16,700 lb. per sq. in.

The corresponding ratio of $f_{\min.}$ to $f_{\max.}$ for this partially reversing stress is about 0.62 as defined in the Appendix, and the total stress range that this surface fiber undergoes during each revolution is about 43,700 lb. per sq. in., a limit far in excess of that which the metal can continuously endure. Checking this result on the basis of the formulæ given in the Appendix, the allowable stress range for unit basic factor of safety for 65,000-lb. T.S. steel is about 39,000 lb. per sq. in., which corresponds to a tension stress limit of about $f_{\max.} = 24{,}000$ lb. per sq. in. The net or basic factor of safety in the original wheel shaft is thus found to be about 0.9, i.e., less than unity, for which the corresponding excess tension stress becomes equal to about $f_{\text{exc.}} = 27{,}000 - 24{,}000 = 3{,}000$ lb. per sq. in.

No record has been kept as to the running time actually required to rupture the original shafts, but judging from the average period of operation of these engines, it is probable that each of the defective shafts made between 100,000,000 and 150,000,000 revolutions prior to failure.

As based upon Stromeyer's fatigue formula as given in the Appendix, the excess stress $f_{\text{exc.}}$ required to produce rupture in the stated number of revolutions would lie between 2700 and 3000 lb. per sq. in. for an alternating-stress cycle. Accordingly, it would appear that the stress curves shown in Fig. 2 have been closely estimated and that the original shafts must have been subjected to a maximum tension stress approaching the elastic limit of the shaft material.

The character of the ruptured section of these shafts is shown in Fig. 3. The high alternating stresses set up in the outermost fibers undoubtedly produced gradual fatigue, which led to a rupture of the surface metal. This irreparable damage greatly weakened the shaft, and as the rupture crept inward, a point was finally reached where the shaft could no longer bear its load.

The fact that three of the original shafts became defective in practically the same place and that each shaft proved serviceable for a period approximating three years virtually precludes a defect in forging but points rather to improper shaft design as the cause of the mishap. In fact, it now appears that the ultimate failure could have been foretold had the underlying stress relations been analyzed in the manner advocated before deciding upon the final shaft dimensions.

Transporting Freight in Interchangeable Containers

A long step toward relieving the tense situation in the transportation lines of the country appears to have been made by the River and Rail Transportation Company of St. Louis, Mo. This company has developed an interchangeable metal container, termed "Trinity Freight Unit," for facilitating the transfer of goods at terminals. *Railway Age* for September 24 describes this container system of freight transportation. Merchandise is placed in the container at a manufacturing plant or in a warehouse and then, locked and sealed, the container is transported by motor truck to a railroad, or to a waterway, where it is transferred to a flat car or to a boat without rehandling the materials.

The complete unit includes a specially constructed flat car, which differs from those now in use on the railroads of the United States only in providing a means of clamping the containers fast to the platform of the car. Estimates, based on present prices, place the cost of equipping a car with five 10-ton units at $1000. A flat car having these special features may be built for the same cost as that required for an ordinary flat car, or existing flat cars may be altered to carry the containers at an approximate cost of $250.

Containers made in a number of different ways are provided for carrying various kinds of material. A type is designed with side-opening doors for package freight, another with top doors and drop bottom for loose bulk freight, and there are other types for refrigerator service and for carrying liquids.

The units are made in capacities of $2^1/_2$ tons and 10 tons each and are proportioned so that five 10-ton units, or twenty $2^1/_2$-ton units, or several units of both capacities, and for any of the different classes of freight, can be carried on a flat car of 50 tons capacity. They are rectangular in form and are substantially constructed of steel plate rigidly reinforced with angle irons to withstand the strains due to the weight of the contents and the transferring of the unit from one vehicle to another.

The system has already been tried and proved successful. The United States Railroad Administration adopted it to facilitate water-rail shipments of war supplies. Twenty of the 10-ton package units were built and gave satisfactory service in the New Orleans district in handling package freight. Estimates based on the performance of these units indicate that the handling of freight is not only greatly expedited but can be handled at from 300 to 400 per cent less cost than with any of the present methods.

Tests on Rear-Axle Worm Drives for Trucks

By KALMAN HEINDLHOFER,[1] PHILADELPHIA, PA.

In this article is recorded a series of tests on worm drives used in the rear axles of motor trucks to determine the efficiencies under load variations. Efficiency curves showing results with four sets of gears in mesh are included. The effect of the oil temperature in the worm thrust bearing, on the efficiency of the drive is shown, higher efficiencies being derived at higher oil temperatures. The author also presents the record of life of four case-hardened steel worms that failed under load.

THE various tests on rear-axle worm drives which are to be described were conducted by the author during an in vestigation of ball-bearing applications. Important data and information were obtained concerning the efficiency of two axles of the same capacity and similar design, the temperature of the worm thrust bearings under full-load conditions, and the life of four worms which broke under load. The testing method employed was that developed by Prof. C. M. Allen and F. W. Roys and described in their paper Efficiency of Gear Drives.[2]

Figs. 1 and 2 show the test arrangement, which is represented diagrammatically in Fig. 3. The worm gears to be tested were mounted in a rear-axle housing and driven by an electric induction motor running 1200 r.p.m. under no load and 1160 r.p.m. under full load. It was possible to change the speed by a transmission having gear ratios of 5.93 : 1, 3.24 : 1, 1.74 : 1 and 1 : 1. The power transmitted was absorbed by an Alden dynamometer, which offered a very smooth and readily adjustable torque resistance. To avoid losses in the differential and the use of an extra dynamometer, the differential was locked. At each end the frame of the driving motor was supported by three disk rollers, which allowed the housing to swing on its supports without friction.

[The testing device, as described in the paper above referred to, permits the reactive force of the motor and the force of the dynamometer to act downward through arms of equal length, at the ends of which are knife edges. A lever with three knife edges mounted upon it, has the two outer knife edges adjusted so that the distance between them is equal to the distance (horizontal) between the dynamometer knife edges. The third knife edge divides this distance into segments whose ratio to each other is the same as the gear ratio. The knife edges of the motor and dynamometer are connected to the outer knife edges of the lever, the high-speed motor being coupled to the long arm of the lever and the middle knife edge being supported on the platform scales. A counterweight and rider are mounted on the lever.—EDITOR.]

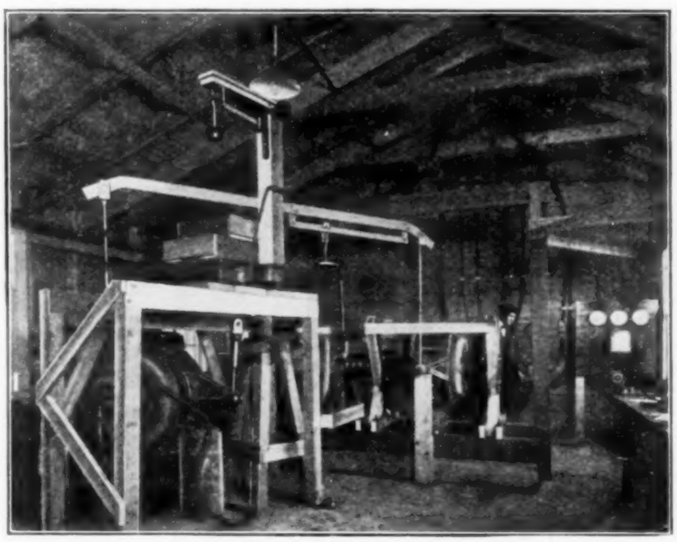

FIG. 1 FRONT VIEW OF AXLE-TESTING DEVICE

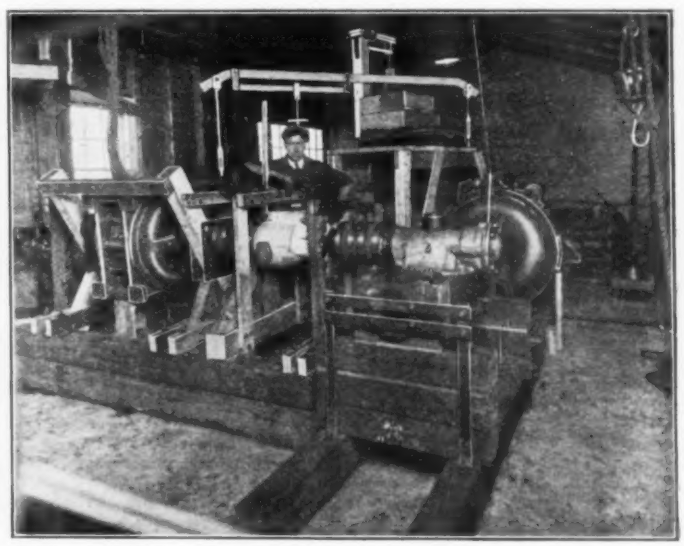

FIG. 2 REAR VIEW OF AXLE-TESTING DEVICE

It will be evident from Fig. 3 that for 100 per cent efficiency the system would be in equilibrium, but since the efficiency is never 100 per cent, the reactive force of the motor will exceed the force of the dynamometer and balance may be restored by shifting the position of the rider weight. The displacement of the rider weight is therefore a measurement of the change of moment, and is a measurement of the power loss.

The motor and transmission, as well as the transmission and worm, were connected by flexible couplings to take care of possible misalignment.

The oil used in the rear axle was Mobil Oil C, and in the transmission, medium mineral oil. The viscosity curves of both oils determined in a Saybolt viscosimeter, are shown in Fig. 4, the vertical scale giving the time, in seconds, required for 60 cc. of oil to pass through a standard orifice.

In order to determine the efficiency of the worm drive the transmission efficiency was determined in a separate test, using a similar apparatus to that shown in Fig. 3. The worm efficiency was obtained by subtracting the transmission efficiency from the total.

dividing

EFFICIENCY TESTS

The first two tests were of the rear axles for a 3-ton truck, designated as Nos. 1 and 2, their engines having a rated capacity of 50 hp. at 1000 r.p.m., the worm ratio being $9^1/_2$ to 1. The efficiency of worm drive and transmission was determined in first, second and third gears, readings being taken at $^1/_3$, $^2/_3$ and full load and $^1/_6$ overload.

The worm is made of low- (0.2 per cent) carbon steel, no nickel, case-hardened and ground, and has four right-hand threads, circular pitch 1.1562, pitch 3.265, lead angle 24 deg. 20 min. The gear is made of phosphor bronze. The worms in the two axles are supported on ball and roller bearings, respectively.

Test results are plotted in Figs. 5 and 6.

In order to ascertain the effect of severe and enduring service on the efficiency, readings were taken on axle No. 1 after running a total of 110 hr. in low gear (196 r.p.m. of worm) and 49 hp. The efficiency reading was taken under the same condition and found to have improved 1 to $1^1/_2$ per cent.

The efficiencies of the transmission are shown in Fig. 7, while the net efficiencies of the worm are shown in Fig. 8.

It is remarkable that the efficiency of the transmission (Fig. 7) is the lowest in direct drive, that is, when the gears are running

[1] SKF Research Laboratory.
[2] Trans.Am.Soc.M.E., vol. 40, p. 101.

For presentation at the Annual Meeting, New York, December 7 to 10, 1920, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

idle. This is due to the power absorbed in churning the oil at high speed, in which case the viscous forces opposing motion are high.

Oil temperature affects efficiency considerably. In case of the Mobil Oil C, higher temperatures in the rear axle housing improve the efficiency. A heavy oil in winter at light loads and high worm speeds, means low efficiency. The effect of temperature in the beginning disturbed the tests until it was found that by starting with heavy loads and finishing with light loads, the temperature could be maintained constant to a satisfactory degree, and thus consistent readings could be obtained. The small figures alongside the curves indicate the oil temperatures in the worm housing.

In connection with the test on axle No. 2, the author wishes to point out that the efficiency in direct drive at low input would have

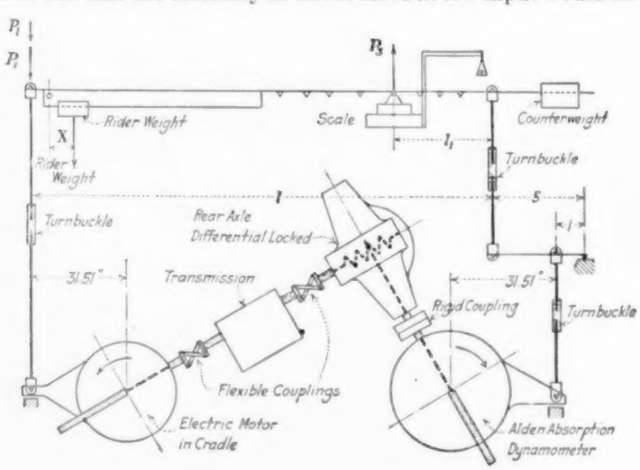

Fig. 3 Diagram of Axle-Testing Device

been somewhat better if a higher oil temperature had existed. These low temperatures were due to precautions being taken to avoid overheating at the end of the test.

Temperature of the Worm Thrust Bearings

On account of the high worm loads carried by the worm thrust bearings, information on the bearing temperature was considered valuable.

To determine maximum temperature conditions, first (low)

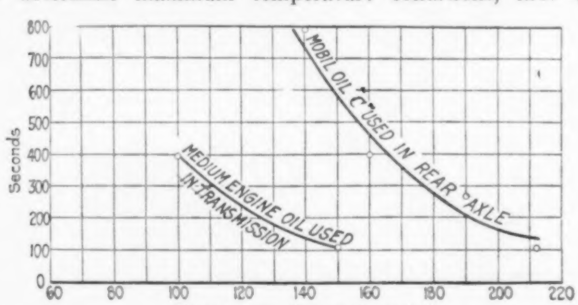

Fig. 4 Curve Showing Variation in Viscosity of Oils Used in Rear Axle and Transmission

gear and full load was considered the most severe. Under this condition axle No. 1 stood up very well, and the maximum bearing temperature was 185 deg. fahr. with an oil temperature in the housing of 275 deg. fahr. after 5 hr. continuous running under an input of 49 hp. Axle No. 2 under same speed and practically same load gave a bearing temperature of 572 deg. fahr. with an oil temperature in the housing of 400 deg. fahr. after 90 min. continuous running under 52 hp. Due to the excessive heat the worm and the thrust bearing were completely destroyed.

It was then decided to modify the test for axle No. 2 to resemble actual conditions such as are encountered by a loaded truck in snow or on a sandy road, with subsequent hill climbing. Due to the damage done in the preceding test, the worm and thrust bearing were replaced by new ones. Curves plotted in Fig. 9 show the temperature rise with the time. The thrust bearing of axle No. 2 shows a final temperature slightly over 200 deg. fahr. in high gear, full speed and 52 hp. In a comparatively short

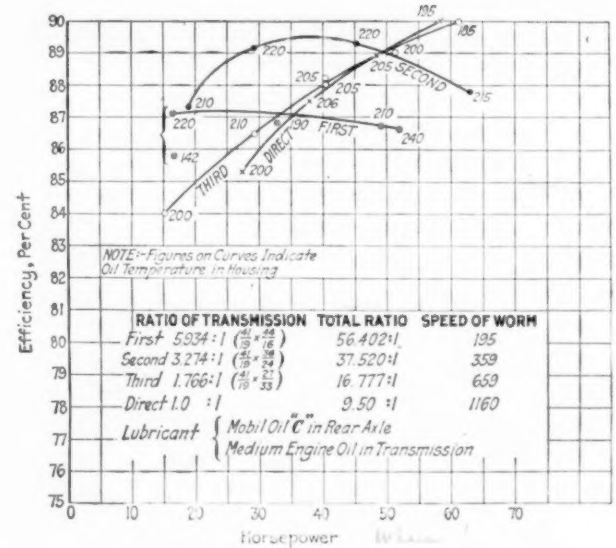

Fig. 5 Efficiency Curves of No. 1 Rear-Axle Worm Drive and Transmission at Different Gears

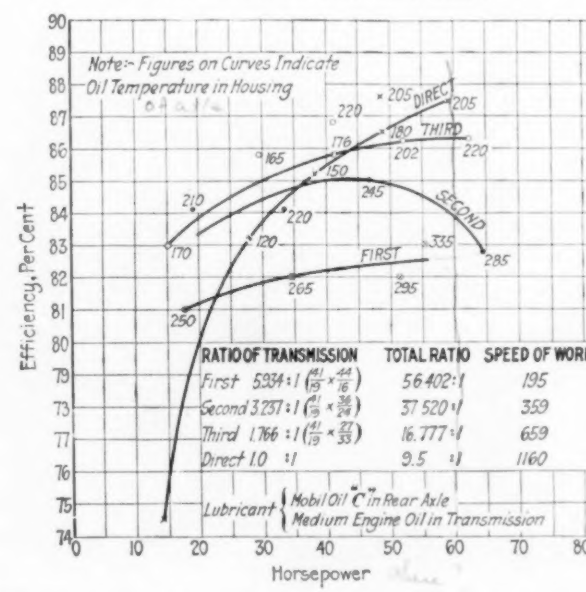

Fig. 6 Efficiency Curves of No. 2 Rear-Axle Worm Drive and Transmission at Different Gears

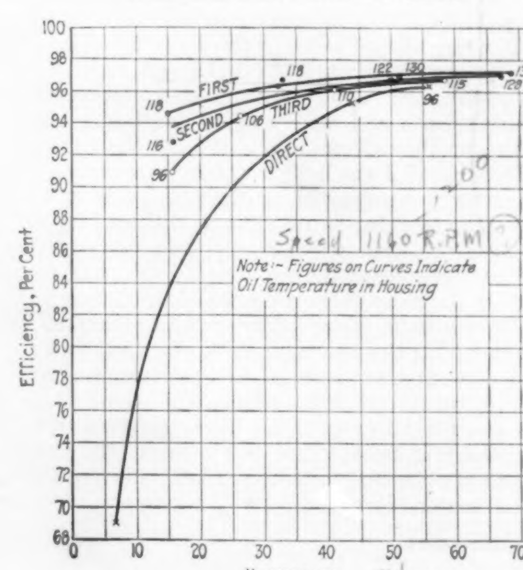

Fig. 7 Efficiency Curves of Truck Transmission at Different Gears

TABLE 1 TABLE SHOWING RESULTS OF FATIGUE TESTS ON WORMS

		A	B	C	D
1	Worm ratio	$9\frac{1}{2}:1$	$9\frac{1}{2}:1$	$9\frac{1}{2}:1$	$8\frac{3}{4}:1$
2	Hp. on motor	49	46.8	41.2	42.2
3	Hp. transmitted to worm wheel	46.5	44.5	39	40
4	R.p.m. of worm	196	196	196	196
5	Net effective torque, in-lb.	14,900	14,300	12,500	12,800
6	Pitch radius	1.63	1.37	1.37	1.39
7	Angle of lead	24°20′	30°26′	30°26′	32°12′
8	Angle of pressure	30°	27°30′	27°30′	27°15′
9	No. of threads	4	4	4	4
10	Tangential component of tooth pressure, lb.	9,150	10,400	9,150	9,230
11	Vertical component of tooth pressure, lb.	11,700	9,200	8,100	7,550
12	Item 11 less a percentage for friction loss	Less 10% 10,500	Less 12% 8,100	Less 15% 6,900	Less 11% 6,700
13	Resultant radial load, lb.	14,000	13,100	11,500	11,500
14	Worm thrust, lb.	18,000	15,500	13,200	13,300
15	Half span, in.	6.2	7.2	7.2	6.6
16	Max. bending moment, in-lb.	68,300	62,600	54,300	51,000
17	Sectional area of core, sq. in.	4.6	2.9	2.9	2.6
18	Life of worm, hr.	118 hr.	46 min.	1 hr. 30 min.	8 hr. 40 min.
19	Life of worm, total no. revolutions	1,390,000	9,000	17,600	102,000
20	Remarks	Thread broken off, core unbroken	Core broken at center	Core broken at center	Core broken at center

time the heat in the thrust bearing became excessive. The break in the curve indicates the period of stop needed for changing gears, knife edges on the balance beam, etc. The slightly higher horsepower input in case of axle No. 2 was due to the difficulty in predetermining the correct scale weights.

Fatigue Tests on Worms

The running tests conducted under uniform speed and load

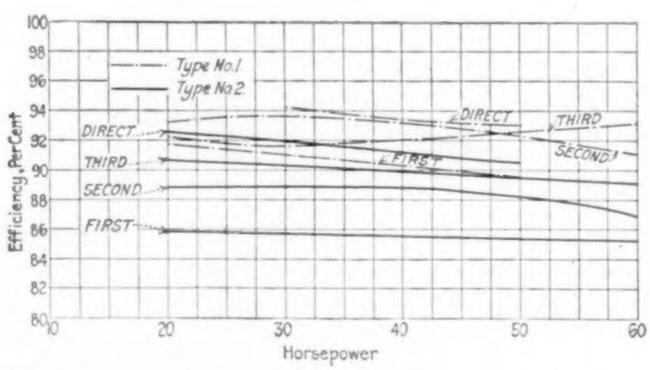

FIG. 8 EFFICIENCY CURVES OF REAR-AXLE WORM DRIVE AT DIFFERENT GEARS

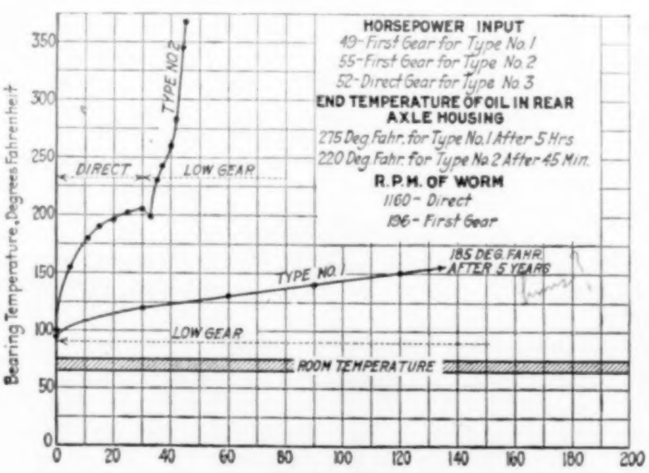

FIG. 9 TEMPERATURE CURVES OF THE WORM THRUST BEARINGS

offered the opportunity to record the life of four worms, three of which were different in design. All these worms broke after a certain number of revolutions under a heavy load. The load, however, did not exceed the maximum which the axle was supposed to carry in low gear.

All worms tested were made of about 0.2 per cent carbon steel. They contained no nickel and were case-hardened, the working surfaces being ground. The test arrangement was the same as shown in Figs. 1 and 2, enabling the input to be accurately determined. During each test the horsepower was kept practically constant.

For the benefit of rear-axle designers a few important endurance data are tabulated in Table 1. Worm designated *A* is the one whose efficiency is shown in Fig. 5. *B* and *C* are identical in design, but different from *A*. *D* has a different worm ratio than *A*, *B* or *C*.

Fig. 10 gives an idea of the worm fractures. In case of worms

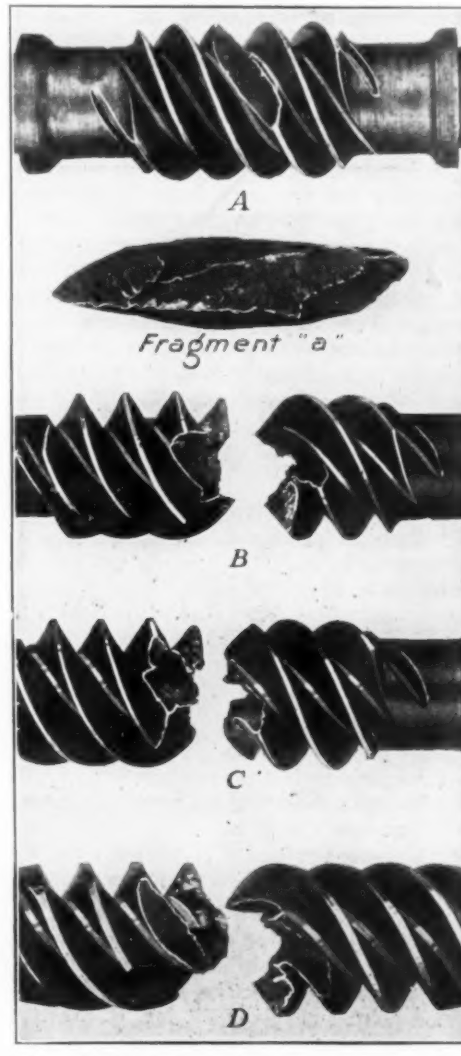

FIG. 10 WORMS THAT FAILED ON FATIGUE TEST

B, *C* and *D* their life could probably have been increased considerably by avoiding sharp corners at the root of the thread. This seems to be a small matter, yet it is of great importance. It is well known from theoretical and experimental investigations that sharp corners tend to concentrate or localize stresses. In case of static loads and ductile material this concentration of stresses is much reduced after the elastic limit is transgressed, which is brought about by the permanent stretching of the metal. The stresses are thus redistributed and will be shifted to other parts originally stressed to a smaller extent.

The case, however, is different with stresses often repeated or reversed and failure may occur even within the elastic limit. The relieving of stresses at the peaks will not take place and the corners will form starting points for cracks, which, when once started, will rapidly progress until the section is so weakened that a sudden break occurs. Thus, it is important, that a radius as large as possible be specified by the designer and checked by the inspector.

Effect of Fittings on Flow of Fluids Through Pipe Lines

By DEAN E. FOSTER,[1] TULSA, OKLA.

In the layout of piping in power plants, heating systems, refineries, and other projects, the engineer is frequently confronted with the problem of making proper allowance for the resistance offered by fittings to the flow of liquids and gases. A number of formulæ and tables have been published giving such information for globe valves and elbows, but none for fittings in general. Konrad Meier, Mem.Am.Soc.M.E., in his excellent treatise entitled, The Mechanics of Heating and Ventilation, has given the subject of the effect of fittings on resistance to flow a very careful study and has presented data thereon in the form of seven charts. In his work of the past several years the writer has found these charts to be very useful in the design of piping for uniform distribution of liquids and gases and in the selection of equipment for producing the necessary force for moving fluids, the only objection being the time required when using them. After some study of the equations used in their construction, however, it was found to be a comparatively easy matter to formulate the following relations between the frictional resistance of pipes of various sizes and the various screwed fittings commonly used, and from these relations to establish tables showing the lengths of pipe equivalent in resistance to that offered by fittings.

For the flow of water through pipe lines Mr. Meier uses the formula

$$H_f = \frac{0.0257}{2g} \times v^{1.86} \times \frac{L}{d^{1.25}}$$

where H_f = loss of pressure in ft.
v = velocity in ft. per sec.
d = diameter in in.
L = length in ft.

This equation agrees within 5 per cent with Gardner S. Williams' formula, which is so widely used in this country.

For resistance offered to flow by fittings, Mr. Meier gives the following:

$$H_r = 1.38r \times \frac{v^{1.86}}{2g}$$

where H_r = ft. of pressure loss per fitting
r = a factor of resistance whose value depends upon the shape of the fitting
v = velocity of the fluid in ft. per sec.

By combining these two equations we obtain

$$L_e = 53.75r \times d^{1.25}$$

where L_e represents the number of feet of pipe equivalent in resistance to a fitting and the other factors as before. Table 1 has been made up from this equation and may be used for water, crude or refined petroleum oils of 32 deg. B. gravity or lighter, or other non-viscous liquids.

For the flow of high-pressure steam through pipes Mr. Meier uses the equation

$$P_f = \frac{W}{144} \times 0.0257 \times \frac{v^{1.95}}{2g} \times \frac{L}{d^{1.2}}$$

where P_f = pressure in lb. per sq. in. to overcome frictional loss.

For resistance offered to flow by fittings he gives:

$$P_r = \frac{W}{144} \times 1.12r \times \frac{v^{1.95}}{2g}$$

By combining these two formulæ we obtain

$$L_e = 43.7rd^{1.2}.$$

There is no reason to assume that the flow of gas or air through fittings should occasion losses differing from those caused by the flow of steam. Hence the writer assumes that the equivalents of Table 2 may be used for all three fluids.

TABLE 1 EQUIVALENT LENGTHS OF STANDARD PIPE TO ALLOW FOR VARIOUS SCREW FITTINGS IN CONDUITS CARRYING NON-VISCOUS LIQUIDS[1]

Formula Used: $L_e = 53.75rd^{1.25}$

Nominal Pipe Size, in.	Actual Inside Diameter, in.	Gate Valve	Long-Sweep Elbow or on Run of Standard Tee	Medium-Sweep Elbow or on Run of Tee Reduced in Size 1/4	Standard Elbow or on Run of Tee Reduced in Size 1/2	Angle Valve	Close Return Bend	Tee through Side Outlet	Globe Valve
Factor of Resistance	....	0.25	0.33	0.42	0.67	0.90	1.00	1.33	2.00
1/2	0.662	0.335	0.442	0.56	0.89	1.20	1.34	1.79	2.68
3/4	0.824	0.475	0.627	0.79	1.27	1.71	1.90	2.52	3.80
1	1.049	0.640	0.844	1.07	1.72	2.30	2.56	3.40	5.12
1 1/4	1.38	0.902	1.19	1.51	2.42	3.24	3.61	4.80	7.22
1 1/2	1.61	1.09	1.43	1.83	2.92	3.92	4.36	5.79	8.72
2	2.06	1.49	1.96	2.50	3.99	5.36	5.96	7.92	11.92
2 1/2	2.46	1.86	2.46	3.13	5.00	6.72	7.47	9.93	14.94
3	3.06	2.46	3.25	4.11	6.66	8.87	9.86	13.11	19.72
3 1/2	3.54	2.92	3.80	4.91	7.84	10.53	11.70	15.56	23.40
4	4.026	3.44	4.53	5.77	9.22	12.37	13.70	18.28	27.50
4 1/2	4.506	3.95	5.20	6.63	10.60	14.22	15.80	21.01	31.60
5	5.047	4.57	6.00	7.68	12.20	16.47	18.30	24.33	36.60
6	6.065	5.72	7.55	9.61	15.30	20.61	22.90	30.45	45.80
7	7.024	6.90	9.10	11.59	18.50	24.84	27.60	36.70	55.20
8	7.981	8.10	10.69	13.60	21.70	29.16	32.40	43.09	64.80
10	10.020	10.70	14.10	17.97	28.70	38.52	42.80	56.92	85.60
12	12.090	12.50	17.80	22.68	36.20	48.60	54.00	71.82	108.00

TABLE 2 LENGTHS OF STANDARD PIPE TO ALLOW FOR VARIOUS SCREW FITTINGS IN CONDUITS CARRYING STEAM, AIR, OR GAS

Formula Used: $L_e = 43.7rd^{1.2}$

Nominal Pipe Size, in.	Actual Inside Diameter, in.	Gate Valve	Long-Sweep Elbow or on Run of Standard Tee	Medium-Sweep Elbow or on Run of Tee Reduced in Size 1/4	Standard Elbow or on Run of Tee Reduced in Size 1/2	Angle Valve	Close Return Bend	Tee through Side Outlet	Globe Valve
Factor of Resistance	....	0.25	0.33	0.42	0.67	0.90	1.00	1.33	2.00
1/2	0.622	0.031	0.41	0.52	0.84	1.12	1.25	1.66	2.50
3/4	0.824	0.044	0.57	0.73	1.17	1.57	1.75	2.33	3.50
1	1.049	0.057	0.77	0.98	1.57	2.11	2.34	3.11	4.68
1 1/4	1.380	0.082	1.07	1.37	2.19	2.94	3.27	4.35	6.54
1 1/2	1.610	0.098	1.29	1.64	2.63	3.52	3.92	5.21	7.84
2	2.067	1.32	1.74	2.23	3.55	4.77	5.30	7.05	10.60
2 1/2	2.469	1.64	2.16	2.75	4.39	5.91	6.56	8.71	13.12
3	3.068	2.13	2.81	3.59	5.72	7.69	8.54	11.40	17.08
3 1/2	3.548	2.53	3.34	4.26	6.80	9.10	10.13	13.50	20.26
4	4.026	2.96	3.90	4.97	7.94	10.65	11.84	15.75	23.68
4 1/2	4.506	3.27	4.45	5.66	9.05	12.14	13.50	17.95	27.00
5	5.047	3.88	5.11	6.42	10.40	13.95	15.51	20.60	31.02
6	6.068	4.81	6.35	8.09	12.90	17.35	19.27	25.60	38.54
7	7.023	5.75	7.59	9.66	15.40	20.70	23.02	30.60	46.08
8	7.981	6.70	8.85	11.20	17.90	24.10	26.80	35.60	53.60
10	10.02	8.75	11.54	14.70	23.40	31.50	35.00	46.60	70.00
12	12.09	10.90	14.40	18.35	29.30	39.30	43.70	58.10	87.40

Many charts and diagrams for the quick determination of steam pipe sizes have been published, but they have all been constructed under the assumption that dry saturated steam was the fluid to be carried. The accompanying chart, Fig. 1, however, solves problems involving the carrying of either dry saturated or superheated steam. In order that its use may be clear the following case has been assumed, the pressure loss in lb. per sq. in. per 100 ft. being desired:

Average steam pressure in line..........	140 lb. abs.
Superheat..............................	150 deg.
Amount of steam to be delivered.........	1700 lb. per min.
Size of pipe............................	10 in. standard

In the solution shown in Fig. 1 the chart is entered on the horizontal line representing 150 deg. of superheat. This line is followed to the left until it intersects the curve representing 140 lb. pressure. From this intersection the dashed vertical line is followed down to its intersection with the horizontal dashed line representing 1700 lb. of steam. From this intersection the inclined dashed line is followed to its intersection with the horizontal line representing 10-in. pipe. The vertical thus determined gives the loss required as 2.08 lb. per 100 ft. Had a 12-in. pipe line been used, the loss would have been only 0.81 lb.

[1] Consulting Engineer, Foster and Gilmore, Mem.Am.Soc.M.E.

For presentation at the Annual Meeting, New York, December 7 to 10, 1920, of The American Society of Mechanical Engineers. All papers are subject to revision.

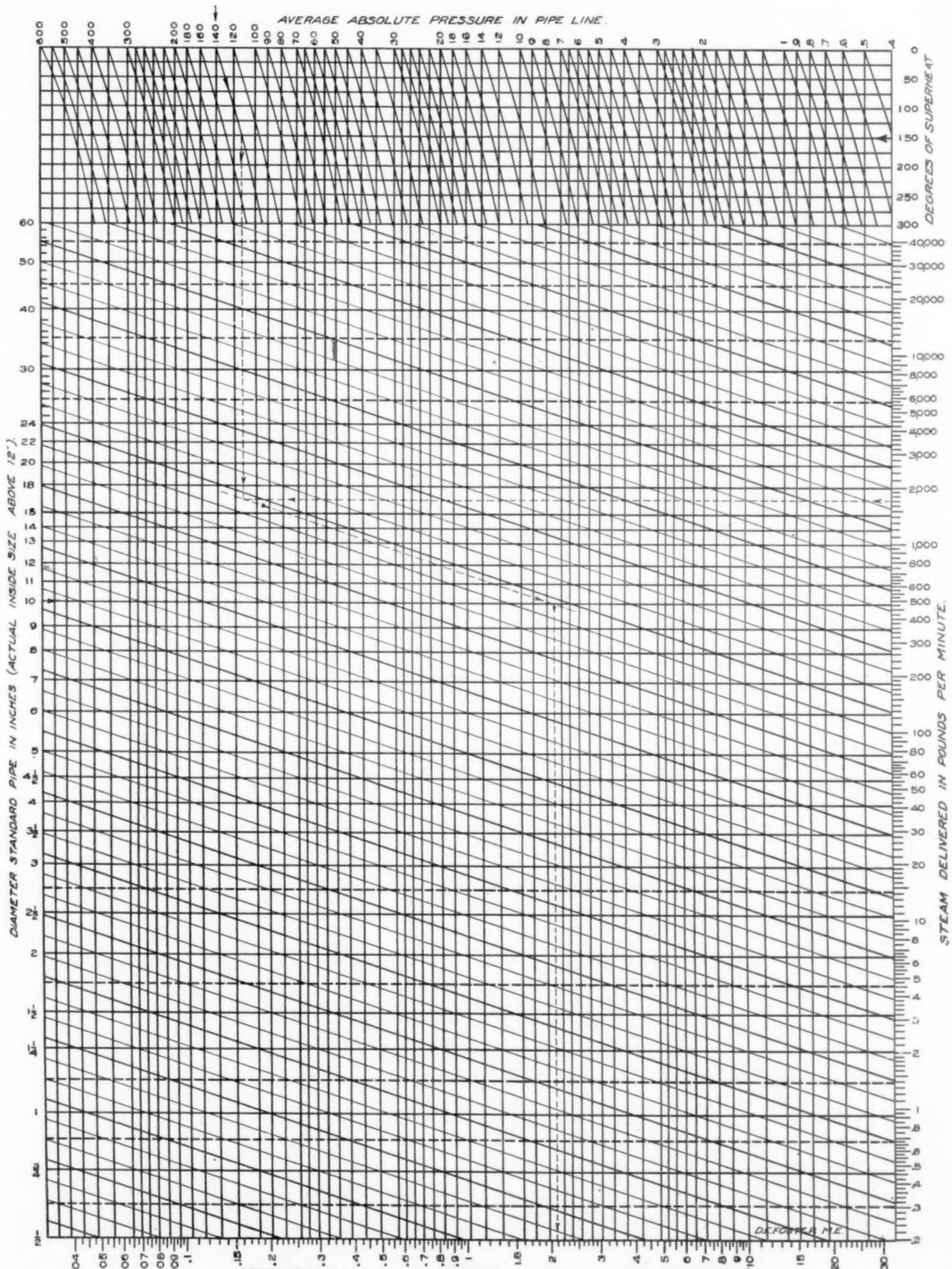

Fig. 1 **Graphical** Solution of Babcock's Formula for Flow of Steam in Pipe Lines

Fig. 1 can be used for the solution of any case where four of the variables are known and the fifth is to be determined. For the solution of problems involving dry saturated steam, enter the chart at the top at the point representing the pressure assumed and follow a vertical line from this point to its intersection with a horizontal representing the desired quantity of steam. The remainder of the solution will be the same as outlined for superheated steam. If the part representing superheated steam were omitted, this chart would be very similar to one constructed by H. V. Carpenter, Mem.Am.Soc.M.E., and published a number of years ago in *Power*.

To show the use of Table 2 an example has been taken of a 6-in. steam line 1000 ft. long, containing 5 gate valves, 3 angle valves, 20 standard tees, and 10 standard ells. From Table 2 for steam, air, and gas, these fittings are found to be equivalent to 332.10 ft. of 6-in. pipe as follows:

5 Gate valves, each 4.81	24.05
3 Angle valves, each 17.35	52.05
20 Standard tees on run, each 6.35	127.00
10 Standard ells, each 12.90	129.00
Total allowance	332.10 ft.
Actual pipe length	1000.00
Equivalent total length	1332.10 ft.

The chart shows that with an initial pressure of 150 lb. and a total loss of 5 lb. pressure or 0.375 lb. per 100 ft. this line will transmit about 225 lb. of steam per min. If the effect of the valves and fittings had been ignored, the calculation would show a capacity of 260 lb. of steam per min. This would have indicated a flow of $11^1/_2$ per cent more than the real capacity of the line. This error in capacity will be the same, no matter what pressure drop is allowed through the line.

Use of Table 1 is illustrated by the solution of the following problem which assumes that a 4-in. line is to handle 26.2 cu. ft. of water per min. through a horizontal run of 50 ft., at which point the line rises at right angles 35 ft., thence runs horizontally 120 ft. to a tee heading a manifold consisting of five pieces of 4-in. pipe 12 ft. long connected by 4-in. tees, each delivering one-sixth of the total quantity of water. A centrifugal pump is to be selected and properly speeded to handle this quantity of water. The pump is to be located 10 ft. above the water surface.

Since the frictional resistance of pipe varies approximately as the square of the quantity of water passing through it, it will be convenient to combine the last 12 ft. of horizontal run with the first tee. This will give us 6 sections of 4-in. pipe each 12 ft. long and having a connecting tee. From Table 1 for liquids we find a 4-in. tee equivalent to be 4.53 ft. of 4-in. pipe, making each section the equivalent of 16.53 ft. in length. From Cox's tables for flow of water through pipe lines we find a loss of 2.563 ft. per 100 ft. for a 4-in. line handling 26.2 cu. ft. of water per min. The loss for the first section which carries all the water will be $16.53 \times 2.563/100$ or 0.424 ft. For the second section, which carries $^5/_6$ of the total, the loss will be as the square of the quantity carried, or $^5/_6 \times {}^5/_6 \times 0.424 = 0.295$ ft.

For the entire manifold the losses will be as follows:

Section 1 $(6/6)^2 \times 0.424$	0.424
Section 2 $(5/6)^2 \times 0.424$	0.295
Section 3 $(4/6)^2 \times 0.424$	0.198
Section 4 $(3/6)^2 \times 0.424$	0.131
Section 5 $(2/6)^2 \times 0.424$	0.047
Section 6 $(1/6)^2 \times 0.424$	0.012
Total loss for manifold	1.107 ft.

For the remainder of the line we have:

Suction line	10
300 diameters for pump	100
First horizontal run	50
Riser	35
Second horizontal run	108
Three 4-in. standard elbows, each 9.22	27.66
Total equivalent length of pipe to Section 1 of manifold	330.66 ft.

and from the foregoing:

Loss on 330.66 ft., 2.563/100 per ft	8.47
Loss through manifold	1.11
Total loss	9.58 ft.

The total pumping head then will be as follows:

Suction head	10.00
Elevation	35.00
Friction head	9.58
Total head	54.58 ft.

CONSTITUTION AND PROPERTIES OF BOILER TUBES

(*Continued from page 605*)

not thus visibly subject to grain growth. Not only was there evident a marked growth in the ferrite grains for the irons ranging in carbon content from 0.006 to 0.251 per cent, inclusive, but in the irons in this range where there was a visible quantity of carbon existing as pearlite, very apparent agglomeration or balling up of this constituent was in evidence.

TABLE 1 EFFECT OF CARBON CONTENT ON GRAIN GROWTH IN DEFORMED IRON WHEN HEATED BELOW THE CRITICAL TEMPERATURE

Carbon Content, Per cent	Number of Ferrite Grains per Square Inch Undeformed	Deformed
0.006	3.9	1.9
0.103	25.4	13.4
0.203	63.4	23.0
0.251	26.3	16.0
0.315	(*a*)	(*a*)

(*a*) Grains too small to count. Photomicrographs from both the undeformed and deformed areas show no appreciable difference in grain size.

Service Comparison between Medium-High- and Low-Carbon Boiler Tubes

Not only do all theoretical considerations point to the procurement of an increased life for boiler tubes through a raising of the carbon content, but the results of some actual tests on which data are now available seem to indicate and confirm this claim.

This test was started in 1916–1917 by placing in the front row of four of the 750-hp. Stirling boilers at the Park Place Heating Plant of the Detroit Edison Co. tubes of a medium-high carbon content averaging around 0.30 per cent carbon, and in four other boilers at the same plant operating under the same loads at about the same time tubes with a carbon content between 0.08 and 0.18 per cent.

The results given in the "Service Test" (Table 2) speak for themselves, for of the medium-high-carbon tubes only about one-half have been replaced, and of the low-carbon tubes, more than a 100 per cent replacement has been necessary.

TABLE 2 SERVICE TEST ON MEDIUM-HIGH- AND LOW-CARBON BOILER TUBES AT PARK PLACE HEATING PLANT, DETROIT, MICH.

Boiler Number	Installation Number	Installation Date	Replacement Number	Replacement Date
HIGH-CARBON TUBES IN FRONT ROW				
3	29	June 19, 1916	27	July 27, 1918
			15	Summer, 1920
6	29	May 9, 1916	13	Sept. 11, 1917
			5	July 15, 1919
			1	Summer, 1920
7	29	June 19, 1917		
8	29	June 9, 1917		
Totals,	116		61	
LOW-CARBON TUBES IN FRONT ROW				
1	29	Sept. 23, 1916	27	July 12, 1918
			5	Summer, 1920
2	29	Sept. 18, 1916	10	Sept. 28, 1917
			27	July 11, 1920
			7	Summer, 1920
4	29	June 14, 1916	18	Jan. 6, 1917
			5	July 27, 1918
			13	June 17, 1919
			5	Summer, 1920
5	10	June 5, 1916		
	19	Aug. 3, 1917	10	August 3, 1917
Totals,	116		127	

This paper has been prepared not for the purpose of suggesting radical changes in boiler-tube composition nor for the purpose of criticizing present boiler-tube manufacturing practices, for all things considered, it is on a very high plane with respect to quality. It has been prepared, however, to present certain facts, especially those relating to grain growth, to which tubes of the commonly accepted composition are so subject; and in view of these acts to question whether tubes with a carbon content varying between 0.30 and 0.35 per cent would not insure longer tube life and safer boiler operation than tubes with a carbon range between 0.08 to 0.18 per cent.

Principles of the Gyro-Compass

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The following brief outline covers the main factors in the development of the gyro-compass up to the present time. It explains briefly the principles of the gyroscope and the simple gyro-compass; discusses the disturbing forces acting on the gyro-compass when on shipboard; and finally takes up the three major problems of design, namely, the compensation of the disturbing forces, the methods of suspension, and methods of damping.

A SUBSTITUTE for magnetism as a directing force has long been sought and in 1852 it appeared that the work of Leon Foucault bid fair to solve this problem by means of the gyroscope. The eminent French scientist found that by the use of the gyroscope, or spinning wheel, a mechanical device could be constructed which, when properly mounted, would indubitably seek the meridian and which depended in no way on the earth's magnetism. The spinning wheel exhibits two properties which distinguish it from inert matter, termed, respectively, "fixity of plane" and "precession."

Fixity of plane expresses the fact that a spinning mass acquires by virtue of its rotation a sort of enhanced inertia which strongly resists any attempt to change the plane of rotation. It is a common error to believe that the gyroscope maintains its plane of rotation in space irrespective of any force applied to it. This is decidedly not true. Even a force of very small magnitude will gradually change the plane of rotation, although it does so in a very novel manner.

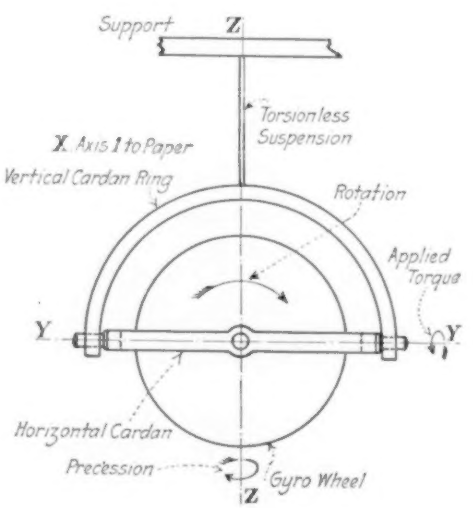

Fig. 1 Simple Gyroscopic System

Precession is illustrated in Fig. 1, which shows a simple gyroscopic system. If torque be applied about, say, the Y-Y axis, with the intent of forcing the plane of rotation of the wheel to rotate about this Y-Y axis, no such result will ensue, but instead the plane will rotate slowly about the Z-Z axis, which is perpendicular to the axis of the applied torque. This action is precession.

The angular velocity of the precessional motion, Ω, will depend upon I, the moment of inertia of the wheel, ω, the angular velocity of rotation of the wheel, and upon T, the torque applied about the Y-Y axis as above, the quantities being connected with the precessional velocity Ω by the equation

$$T = I\omega\Omega$$

The direction of procession will depend on the direction of rotation of the wheel as well as upon the direction of the applied torque, the relation being correctly given in Fig. 1. A reversal either of the direction of the torque or the rotation of the wheel will change the direction of precession, whereas a reversal of both of these will not change the direction of the precession.

Simple Gyro-Compass

With these facts in mind the explanation of the Foucault compass becomes very simple. The elements of the device are shown in Fig. 2. A gyroscope is so mounted in cardan rings that it may freely turn in any direction and the entire system is perfectly balanced about all three of the mutually-perpendicular axes, save only the axis Y-Y, about which it is made slightly pendulous.

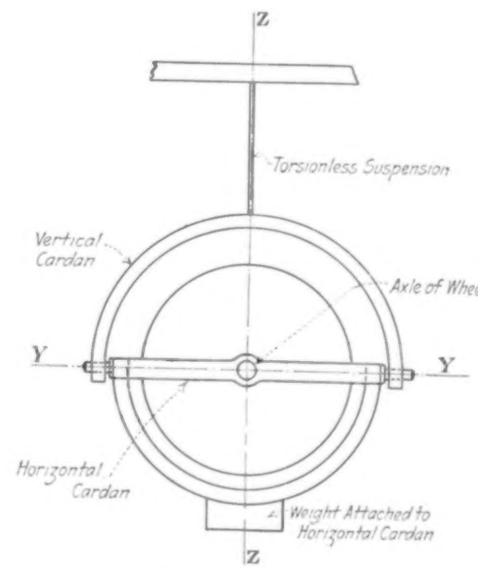

Fig. 2 Simple Foucault Compass

Let us suppose such a device set up on the equator of the earth, with the axle pointing east-west, as shown in position 1, Fig. 3. It is obvious that the direction of the perpendicular at any point on the equator is continually changing, being rotated in a clockwise direction, when viewed from the south, once in 24 hr. The gyroscope, on the other hand, due to its property of fixity of plane, will resist this rotation, with the result that as the earth rotates

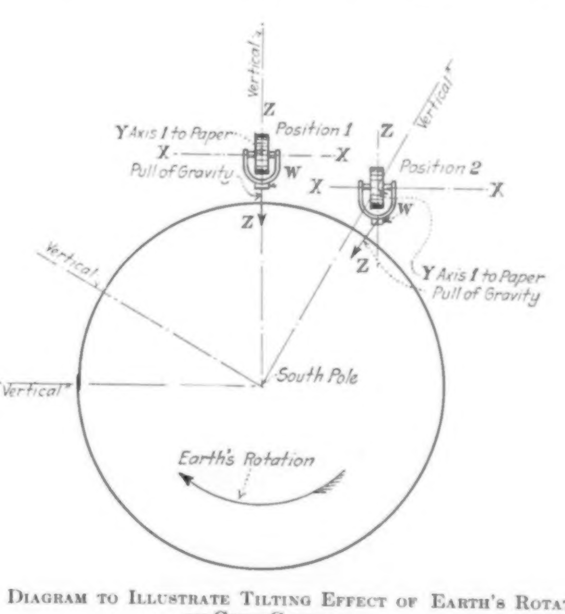

Fig. 3 Diagram to Illustrate Tilting Effect of Earth's Rotation on Gyro-Compass

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the east-pointing end of the wheel will rise with respect to the earth's surface as shown in position 2. As soon, however, as this occurs the weight on the bottom of the wheel case will introduce a couple about the Y-Y axis, due to the pull of gravity, and the phenomenon of precession occurs, causing the wheel to rotate about the vertical Z-Z axis.

A consideration of the foregoing action will show that the east end of the axle will continue to rise and that the weight will act until the axle has passed through the meridian plane, after which the earth will act to depress this end of the axle, finally bringing it into the horizontal. As soon as the axle is horizontal the gravity couple vanishes and the precession ceases. However, the earth continues to act on the instrument, the axle is again tilted and the wheel again swings back toward the meridian plane. Thus the compass continues to perform a series of oscillations back and

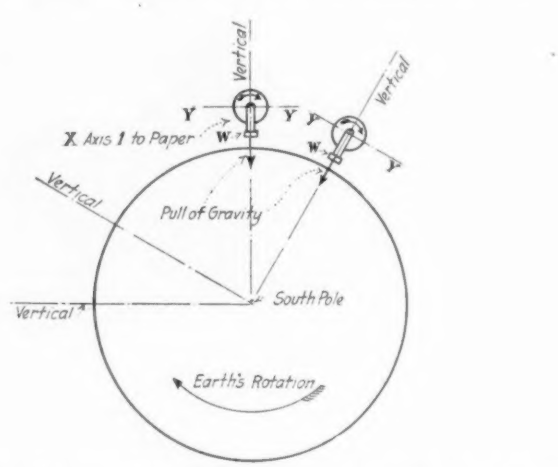

Fig. 4 Gyro-Compass in Equilibrium in Respect to Effect of Earth's Rotation

forth across the meridian until damped out by friction or other means. It will at once be apparent from Fig. 4 that when the compass is at rest with the axle in the meridian and horizontal there is no tilt introduced by the earth and the system is in equilibrium. It may also be readily shown that the action is the same

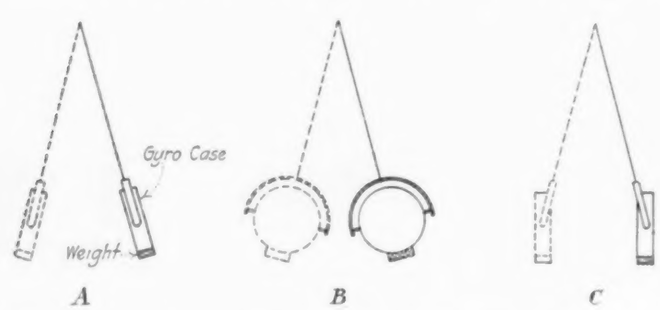

Fig. 5 Diagram Showing Effect of Intercardinal Accelerations

as that described when the compass is located at any other latitude than the equator, with the exception of a small error introduced by the vertical component of the earth's rotation.

It is thus seen that the compass derives its directive force from the rotation of the earth and the force of gravity acting on the pendulous mass of the wheel. In reality an instrument such as that described functions perfectly—granting the necessary degree of mechanical refinement—when placed on a fixed platform where forces other than those mentioned cannot be impressed on the system. However, when the Foucault pendulum is placed on a moving platform, such as a ship at sea, other forces are impressed on it, due to the motion of translation of the ship over the sea and the motions due to wave action. The forces resulting from these causes are in no way to be distinguished from the useful or directive force and are in fact many times greater in magnitude than the useful force, so that under these conditions the instrument becomes inoperative.

It was this fact which delayed the introduction of the gyrocompass in navigation for nearly sixty years after its discovery; and it was the solving of this problem which acted to produce the varied forms of compass which it is the purpose of this paper to describe.

Disturbing Forces Acting on the Compass

We may broadly divide the disturbing forces acting on the compass at sea into two classes: First, those due to the motion of translation of the ship; and second, those due to motions of the ship about various axes fixed in relation to the ship: to which may also be added the error introduced by the vertical component of the earth's rotation, and in some cases small errors due to elements of the compass design. Of these the elimination of forces due to the rolling and pitching of the ship has largely dictated the major factors of the compass design.

These rolling forces, acting on the simple compass or pendulous gyroscope, exhibit their effects chiefly on intercardinal headings, being theoretically absent on north-south or east-west headings, and increasingly troublesome up to 45 deg. from these directions.

A convenient method of investigating these rolling forces is to place the complete compass on a pendulum which may swing in a plane making a known angle with the plane of the meridian. In the first case, suppose this plane to coincide with the plane of the meridian. Then, if the compass wheel is not running and the supporting pendulum is swung, the pendulous mass of the wheel case will cause the case to line up with the pendulum, due to the combination of the forces of gravity and acceleration, as shown at A in Fig. 5. When the wheel is spinning, the case will not line up with the pendulum, since it is stabilized about the east-west axis, and the force of acceleration on either end of the swing will therefore be balanced by a gyroscopic reaction. (C, Fig. 5). These forces are equal and opposite on each end of the swing and no disturbance of the compass will result. Should the plane of swing of the pen

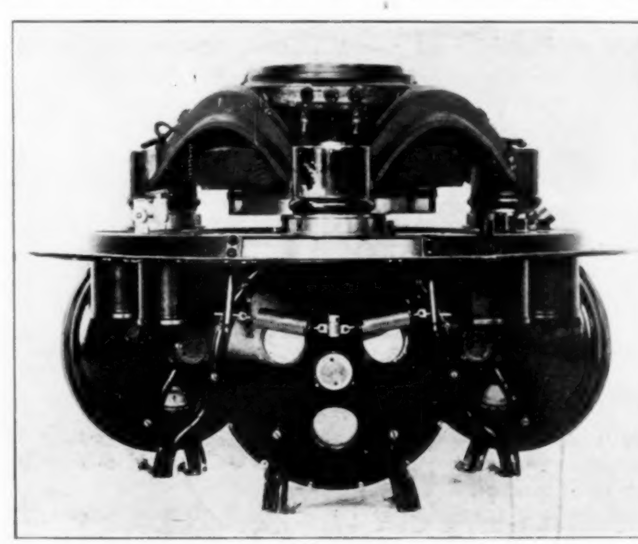

Fig. 6 Sensitive Element of the Anschutz Compass

dulum be east and west, the case will swing freely about the axle of the wheel, and again no disturbing force will result. (B, Fig. 5).

Assume now that the plane of swing makes an angle with the meridian of, say, 45 deg. There will be a component of swing in a north-south direction which will cause a force to be impressed on the pendulous mass, and, as before, it will be equal and opposite on each end of the swing. In addition to this, there will be a movement of the case about the axle of the wheel, due to the east-west component of the swing. This latter motion will cause the point of application of the force of acceleration to be shifted from one side to the other of the vertical axis; and thus, while the impressed force will be equal on each end of the swing, and in an opposite direction, it acts to form a pulsating couple about the vertical whose direction is always the same.

Another way of regarding this phenomenon is to consider that whereas the wheel when spinning is stabilized about an east-west axis, it is perfectly free to rotate about the north-south axis, thus

causing the apparent moments of inertia about these two axes to be widely different. The result of this is that when forces tend to rotate the system about any horizontal axis other than the major axes mentioned above, a torque is set up about the vertical which ultimately displaces the compass from the meridian.

Compensation of the Disturbing Forces

From this description it is obvious that the simplest way of remedying the difficulty is to stabilize the compass in both directions, or, in other words, about the north-south axis as well as about the east-west axis, and one of the earliest methods was based on this principle. Fig. 6 is from a photographic view of the sensitive element of the Anschutz compass. This compass uses three wheels, all attached to the orienting element, one of which operates in the same manner as the Foucault pendulum, the other two being mounted with their axles at an angle to each other and to the main wheel. By this method the apparent moment of inertia of the system about the north-south axis is greatly increased and at the same time a portion of the useful directive force of both of the auxiliary wheels is utilized to orient the compass on the meridian.

In a later form of the Anschutz compass for use on submarines and other small craft subjected to violent rolling, a fourth wheel is added, which serves only as a stabilizer, the axle being vertical.

It is to be noted, however, that in the Anschutz compass complete stabilization of the sensitive element is not aimed at, but rather the reduction of the disturbing tôrque to within a limit where its effect on the compass will not be detrimental. On the other hand, a number of attempts have been made to solve the problem by the independent stabilization of the platform on which the sensitive element is mounted. None of the attempts has been

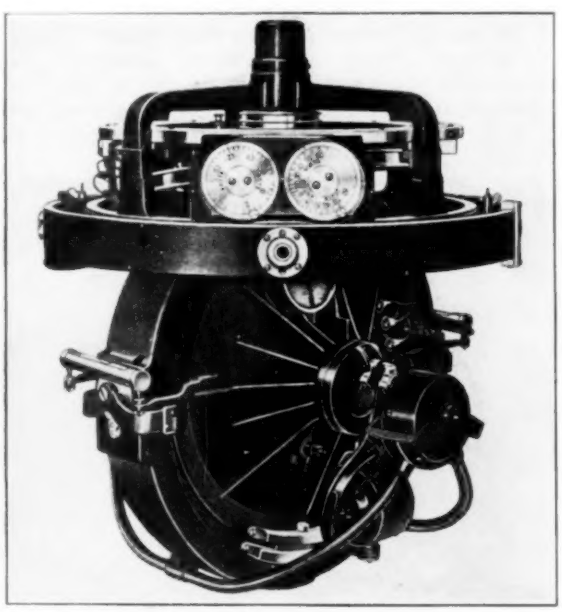

Fig. 7 Sperry Gyro-Compass, Showing Floating Ballistic

so far successful, due, probably, to the difficulty of maintaining the necessary accuracy in the stabilizing apparatus. Numberless trials have demonstrated the fact that it is practically impossible to stabilize a platform on a rolling ship to anywhere near the accuracy required for this purpose.

Another early solution of the problem was the ingenious method developed by the Sperry Gyroscope Company. This method consisted in stabilizing the point of attachment between the gyroscope and the pendulous mass as shown in Fig. 7. The stabilizing device, known as a "floating ballistic" is essentially a pendulum stabilized by a small gyroscope. We find that there again the stabilizing principle is used only to reduce the magnitude of the disturbing forces, and neither the Anschutz principle of three wheels, nor the Sperry floating ballistic, completely compensates.

In 1916 and 1917 a form of compass was developed by Harry L. Tanner, of the Sperry Gyroscope Company, in which complete compensation of the disturbing forces was accomplished. This compass, a photograph of which is shown in Fig. 8, and a line drawing in Fig. 9, utilizes two wheels of equal size and rotating at equal speeds but in opposite directions. One of these wheels is mounted as in the Foucault pendulum and may be regarded as the compass wheel. The second wheel, located to the east of the meridian and known as the east gyro, precesses in a direction opposite to that of the compass wheel under the influence of disturbing forces, and this fact is utilized to impress a force on the west wheel equal and opposite to the disturbing torque; this torque being transferred between the wheels by means of a yielding connec-

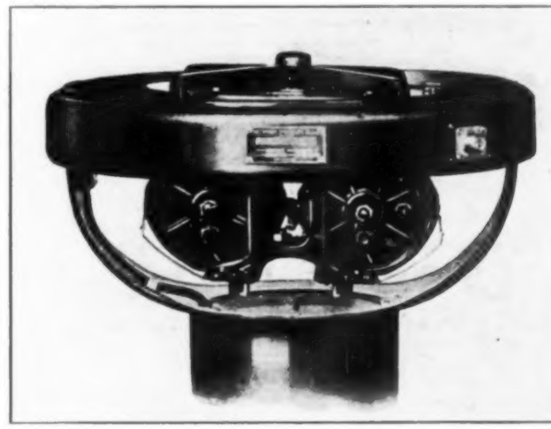

Fig. 8 Sperry Twin Gyro-Compass

tion between them. At the same time the mounting is such that a large portion of the available directive force of the east wheel is transferred to the west and thus utilized. The compass is completely compensated and was adopted by the U. S. Navy for

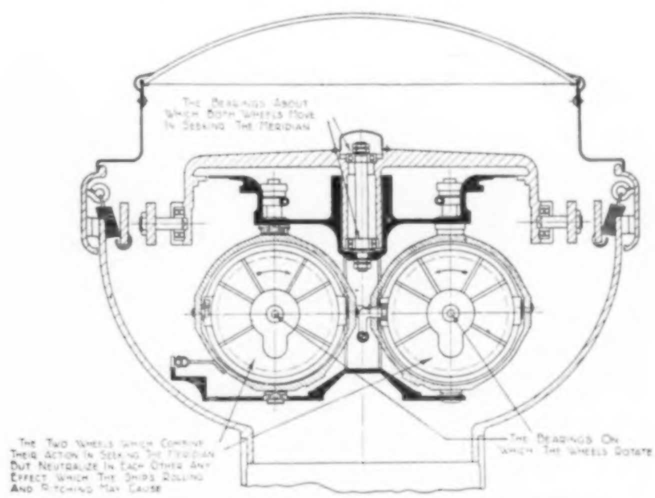

Fig. 9 Partial Section of Sperry Twin Gyro-Compass

use on destroyers, a class of vessels whose rolling characteristics are notorious.

In the last year a new method of compensation has been developed in the United States by the Sperry Company and in England by Perry and Brown. This consists of the use of a non-pendulous wheel, the gravity couple being introduced in a novel manner. The device, the elements of which are shown in Fig. 10, consists of a gyroscope which is perfectly balanced about all of the three axes. On both the north and south sides of the gyro casing and attached to the casing are bottles containing mercury which are connected by means of a small tube. The action of the device as a compass is then very similar to the simple compass in that the earth acts to tilt the wheel as usual, whereupon the mercury flows from the higher to the lower bottle, thus upsetting the equilibrium about the east-west axis. The torque thus generated causes precession about the vertical axis as before. It should be noted, however, that this torque is oppositely directed

to that generated by the usual pendulous mass and therefore it is necessary to rotate the wheel in a direction opposite to that of the ordinary compass. In other words, the wheel must rotate in a counterclockwise direction when viewed from the south.

The explanation of the compensating features of this type of compass lies in the fact that the motion of the mercury from one bottle to the other, under the influence of the forces set up by the

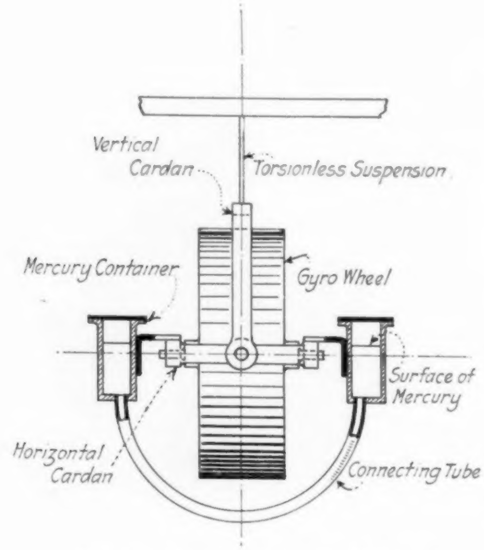

Fig. 10 Mercury Ballistic Compass

rolling of the ship, is out of phase with the motion of the compass in its gimbal rings. While the principle involved is new and no great number of compasses built on this principle have been in service, very exhaustive trials of the instrument have been made in comparison with other standard compasses. All of these tests show that the compensation is practically perfect, in addition to which the simplicity of the instrument strongly recommends it.

In Fig. 11 is a view of the Perry-Brown compass and Fig. 12 shows the mercury attachment or "mercury ballistic" of the Sperry compass, the mercury bottles being indicated by the arrow.

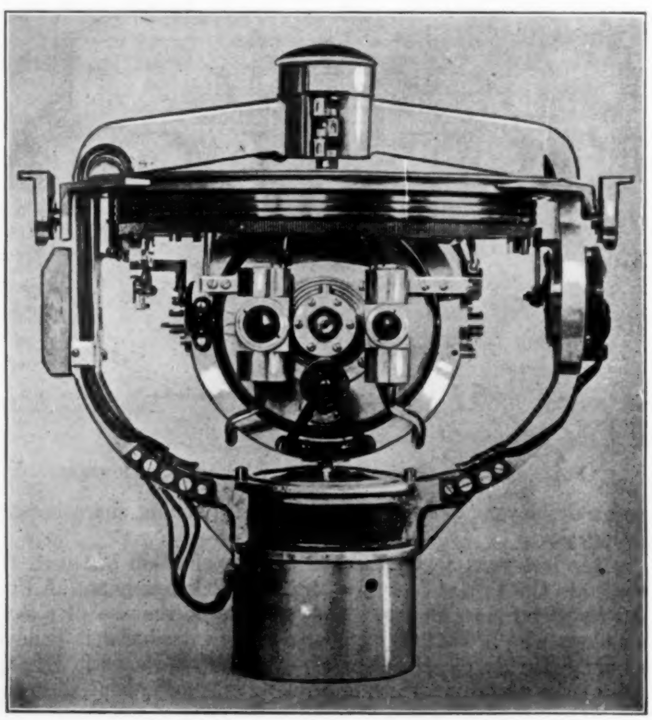

Fig. 11 Perry-Brown Compass

Methods of Suspension

Perhaps of equal importance to the problem of compensation, from the standpoint of the designer of gyro-compasses, is the question of suspension of the sensitive element. While the directive force of the gyro-compass is many times larger than that of the magnetic compass, in most forms of the instrument the masses to be oriented are more than proportionately greater; therefore some means of carrying these masses on a suspension bearing must be devised which is as nearly as possible without friction.

The mercury float forms a very simple method of suspension which immediately suggests itself from the somewhat similar mounting of the magnetic needle in the type known as the liquid compass. The Anschutz compass utilizes the mercury suspension with considerable success and has done so for a number of years. Its great advantage is its simplicity, but on the other hand a number of practical difficulties present themselves. The mercury collects dust from the air and also oxidizes rapidly unless it is surrounded by some non-oxidizing atmosphere such as hydrogen. When the metal becomes dirty or oxidized the sensitivity of the mounting is greatly decreased.

In the original compass constructed by Foucault a filament suspension was employed similar to that used today for galvanometers, oscillographs and similar instruments. Such a suspension was very sensitive, but, of course, was not suitable for shipboard use since it was not capable of making a complete revolution in azimuth. The Sperry Company applied this torsionless-filament suspension to the practical instrument in a manner which has proved so successful that it has been used on all of the various types of compasses which they have designed. It consists essentially of a suspension head carrying a filament consisting of a bundle of very fine piano wires, to the lower end of which is attached the sensitive element. When the sensitive element of the compass turns in azimuth, or the binnacle turns relatively to the sensitive element, this filament is continuously unwound by means of an electrical follow-up system, the elements of which are shown in Fig. 13. It consists of a so-called phantom element, driven in azimuth by an electric motor. As shown in the figure the motor is controlled by trolley contacts operated by the motion of the sensitive element in azimuth relative to the phantom. This suspension is very sensitive and has the additional advantage that a continuous, small oscillation of the phantom relative to the sensitive element is maintained, which acts to reduce the friction of the vertical guide bearings necessary in any type of suspension.

Fig. 12 Mercury Ballistic Attached to Sperry Compass

The Perry-Brown compass uses a form of suspension which has also shown great sensitivity. It is similar in principle to the oil-float thrust bearings used on vertical turbines and similar machinery. A small pump is employed to force oil between the surfaces of a step bearing, thus maintaining a perfect film for the separation of the surfaces. The pulsations of the pump give the sensitive element a small up-and-down oscillation and thus acts as a means of reducing the static friction of the vertical guides as in the Sperry instrument.

The jeweled point has frequently been suggested and tried as a gyro-compass suspension, but has never met with any measure of success, due principally to the large weights which must be supported on extremely small areas.

Methods of Damping

The third major design element, and one which has been the subject of considerable study and which has resulted in many different solutions, is the means for damping the oscillations of the compass system in azimuth. With the very sensitive suspensions which must be employed, the compass will continue to swing back and forth across the meridian for many hours without coming to rest and some special means must be employed to damp these oscillations in a reasonable length of time. The damping employed is generally very large, usually from 60 to 90 per cent. Since in all compasses so far constructed the period has had to be fixed at 85 min. of time, even with a very high damping factor, several hours are required for the compass to settle on the meridian.

An early solution of the damping problem was that employed in

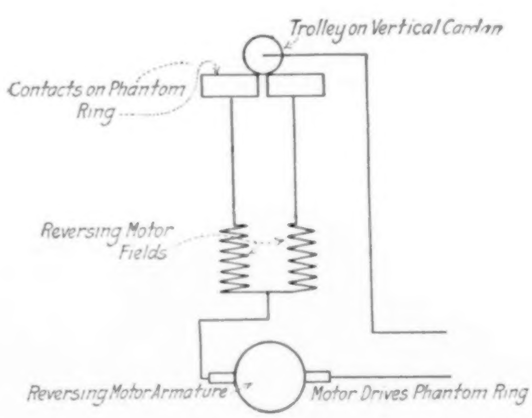

Fig. 13 Elements of Sperry Electrical Follow-Up System

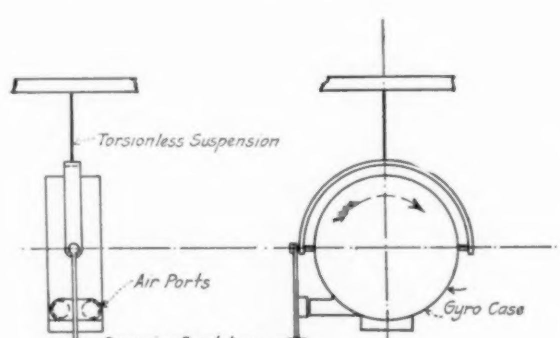

Fig. 14 Anschutz Air-Damping Device

the first Anschutz compass, which consisted of two air jets controlled by a pendulum mounted on the case of the wheel, as shown diagrammatically in Fig. 14. The air pressure was supplied by the rapid rotation of the wheel, the nozzles being so arranged that when the wheel was tilted by the earth's rotation one or the other of the nozzles was opened, causing a reaction about the vertical axis which caused precession in a direction to bring the axle back into the horizontal plane. It is obvious that this action will slow down the motion of the wheel in azimuth and that thus the necessary damping will be secured. The controlling pendulum was not stabilized, but this did not seem to interfere with the action of the device, since its average position, of course, was vertical. Various practical difficulties arose with the device in practice, however, and it was early abandoned.

In the Sperry compasses the damping is secured in connection with the power-driven phantom element. In the compass known as the "Mark I" the pendulous mass, instead of being made an

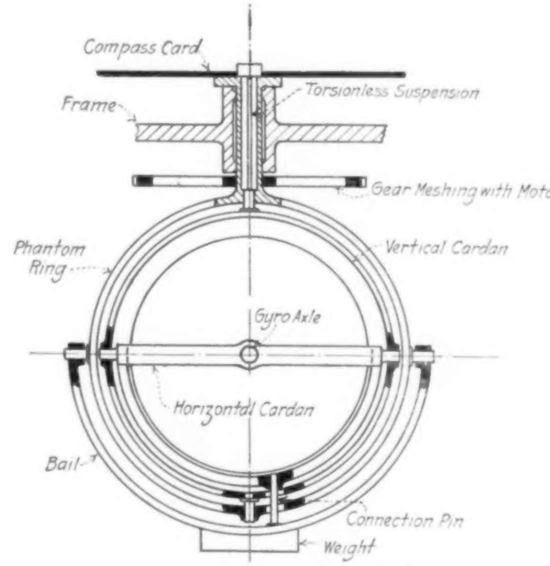

Fig. 15 Sperry Mechanical Damping Device

integral part of the wheel case, is supported on the phantom element on horizontal bearings. The attachment of this mass to the wheel is made slightly to the east of the vertical, and thus when the wheel tilts a large reaction is applied about the horizontal

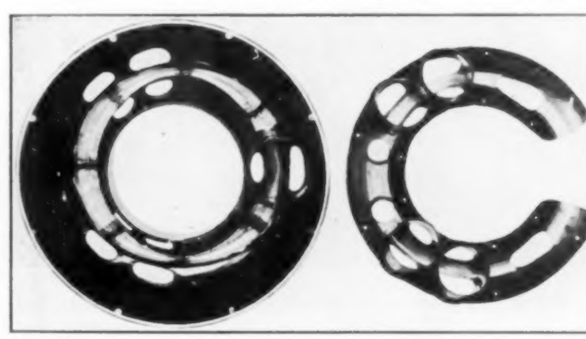

Fig. 16 Anschutz Damping Tanks

axis to secure the directive action and a small reaction about the vertical axis to effect damping.

In the present Anschutz compasses damping is obtained by the use of a flow of oil from the north to the south side of the horizontal axis through very small orifices, the action being very similar to that of the mercury ballistic described above, except that the flow of oil is made so slow that it is out of phase with the oscillation of the compass in azimuth. The oil thus is continually acting to oppose the torque of the main gravity couple, and the oscillations are thus damped. In the Anschutz compass the oil is allowed to flow through a number of reservoirs in series, the openings between the reservoirs being very small. A photograph of the damping tanks is shown in Fig. 16.

Having solved the three major design problems outlined above, the question of building a successful working instrument resolves itself largely into a question of correct mechanical design and excellency of workmanship. The delicacy of the instrument is such that the utmost care must be exercised in both the design and construction to insure the correct and permanent alignment of the parts and the reduction of friction about all axes, to insure freedom from vibration and similar factors.

The Heat-Insulating Value of Cork and Lith Board

Results of a Series of Tests Conducted at the Engineering Experiment Station of Kansas State Agricultural College, Showing Cork Board to be Superior to Lith Board as a Heat-Insulating Material

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The following paper treats of a series of tests made at the Engineering Experiment Station of the Kansas State Agricultural College for the purpose of determining the conductivity and heat-transmitting properties of cork board and lith board. The apparatus employed is described in detail, and the procedure followed in the experimental work is carefully outlined. Formulae for calculating results are also presented. The results obtained by the authors show that as a heat-insulating material cork board is slightly better than lith board; that is, for the samples tested the lith board had a conductivity approximately 5 per cent greater than that of the cork board.

In the following paper are presented the results of a series of tests which were conducted at the Engineering Experiment Station of the Kansas State Agricultural College upon the heat-insulating properties of two refrigerating materials—nonpareil cork and lith board. The general arrangement of apparatus used for the tests is shown in Fig. 1. The test box itself is made of nonpareil cork board and is a cube whose internal dimensions are 2 ft. square. One side of this box is removable for the insertion of specimens of other materials and within it are three resistance

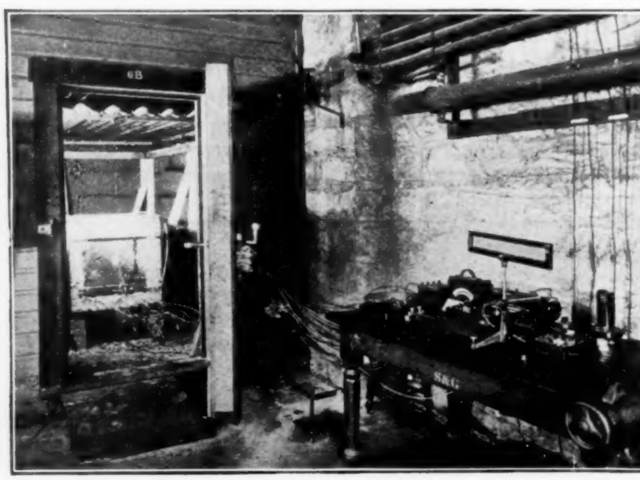

Fig. 1 Apparatus Used in Testing the Heat-Transmitting Properties of Cork and Lith Board

coils which serve as an electric heater during the test. These coils are arranged so that one, two, or three may be joined in series, thus making it possible to vary the intensity of the heat supply. Current is supplied by a 220-volt d.c. line and in order to maintain a uniform voltage at the heating element, a 32-volt storage battery is floated across the supply main. A variable resistance is used to regulate the current input.

The electrical energy consumed by the heating coils is measured by a single millivoltmeter, for through the use of a multiplier, a shunt and a two-way mercury switch the same instrument is made to measure both the impressed voltage and amperage supplied to the coils.

At regular intervals during the test temperature measurements were taken at the internal and external surfaces of the top, bottom, front, and sides of the test box, care being taken in inserting the thermometer to eliminate all possible influence from the air, both external or internal. Temperature measurements were also taken on the front side of the test box, at points 2 in. and 4 in., respectively, from both internal and external surfaces (see Fig. 3).

These temperature measurements were accomplished by the use of thermocouples, made from No. 12 gage copper and constantan wire welded together to form the junction. Since the range in temperature during such an investigation would be low and the consequent electromotive force small, the most convenient method for the measurement of the impressed electromotive force produced by the thermocouple was by balancing it with a standard electromotive force.

The wiring diagram of the temperature-measuring equipment is shown in Fig. 2. The various thermocouples are joined by means of a 14-point switch to the portable potentiometer indicator and in order to produce a more sensitive potentiometer this instrument was of a special design, being provided with connections for a sensitive external galvanometer, which made possible temperature measurements of great accuracy. The scale division of the instrument gives a direct reading of 0.01 millivolt, so that it is possible to estimate to 0.001 millivolt.

The thermocouples with their cold ends maintained at 32 deg. fahr. by an ice bath were calibrated throughout their range of use against a standard mercury-in-glass thermometer. This calibration was accurate to 0.5 deg. No calibration of the thermocouples was made below the 32 deg. fahr. point, as the deviation of the calibration curve above and below this point is probably negligible.

The refrigerator or thermal testing room was 9 ft. by 12 ft.

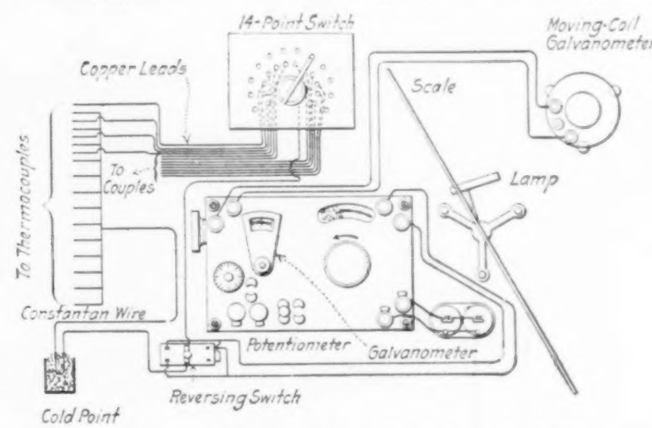

Fig. 2 Wiring Diagram of Temperature-Measuring Equipment

and 10 ft. high. It contained 600 ft. of 2-in. direct-expansion ammonia piping and its walls, floor, and ceiling were insulated with cork board. The refrigerating equipment includes a 5-ton Frick ammonia-compression system, and a 1-ton York machine used as an auxiliary. The ammonia compressor is steam-driven. A pressure gage is inserted in the evaporating coils so that the pressure in the coils can be regulated as desired by opening or closing the suction valve to the compressor or the expansion valve to the coils. Since the boiling point of the ammonia in the evaporating coils is dependent upon the pressure, this regulation gave an indirect means of controlling the temperature in the refrigerator.

Method of Testing

The method of testing was as follows: The test box with its equipment was first placed in the refrigerator. The refrigerating machine was then started and the pressure in the evaporating coils so regulated that the desired temperature in the refrigerator

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would be produced. No other regulation of the refrigerating equipment was made, except that of maintaining the pressure constant in the evaporating coils. While it was impossible to predict the exact temperature that would result with this regulation, the final temperature when conditions became adjusted remained practically constant at a value of approximately 10 deg. fahr. Lower temperatures were possible but required a longer period of operation before conditions became constant.

As a preliminary, temperature readings of two thermocouples, one inside and the other outside the test box, were taken, and when these became constant the test was then started. The length of test was one hour, and readings of the electrical energy supplied and the temperatures as indicated by the various thermocouples were recorded every 10 min.

Since no standard method of procedure has been suggested for the testing of heat-insulating materials along the lines followed in the present work, preliminary tests were first made in order to establish such a method. These tests were to determine the effect of the temperature of the source of heat supply upon the various results, and the probable time that would be required for a variation in the temperature external to the test box to be transmitted to the interior.

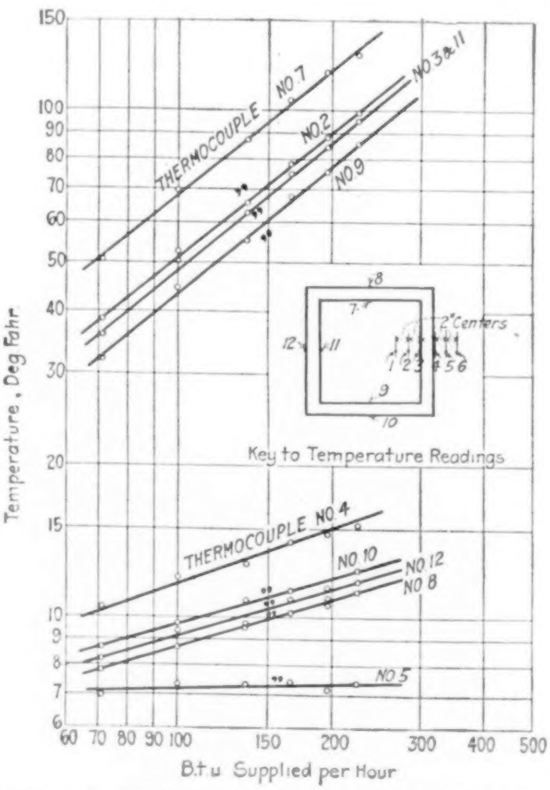


FIG. 3 TEMPERATURE READINGS OBTAINED IN TEST SERIES NO. 1 ON CORK BOARD

From these preliminary results it was concluded that the heating element should consist of the three coils in series as this produced more uniform conditions in the interior of the box, and the insulating effect of the inner air film would approach a condition similar to that found in actual installations. With three coils in series and a current input sufficient to produce a temperature of 70 deg. fahr. in the interior of the box when the external temperature was 10 deg. fahr., the temperature of the heating element was 170 deg. fahr.

It was also shown by these preliminary tests that at least $2^1/_2$ hr. would be necessary, after conditions external to the test box became uniform, before the internal temperature conditions could be expected to become constant. Furthermore, if after external and internal conditions became constant, external conditions for some uncontrollable reason varied, the internal temperatures could reasonably be expected to remain uniform for a period of 2 hr.

Following these preliminary tests the investigation of the insulating properties of both cork and lith board were then made. These tests consisted of two series:

Series 1. These tests were made to show the heat-insulating properties of cork. The external temperature of the test box was maintained constant at approximately 10 deg. fahr. while internal conditions were varied by means of the electric heater described above. Temperature measurements were taken at the internal and external surfaces of the top, bottom, front and back sides of the test box and also at points 2 and 4 in., respectively, from the internal and external surfaces of the front side (see Fig. 3).

Series 2. These tests were identical with those of Series 1, but the front side of the cork-board test box was replaced by a 3-in. lith board.

Method of Calculating Results

In calculating the results from the tests of Series 1, the conductivity of the cork was assumed constant for the various temperatures involved in each test. The heat equivalent of the electrical energy was equated to the heat conducted through the various sides as shown by the following equation, the temperature difference of the two measured sides being assumed as the average of the front and back temperature differences.

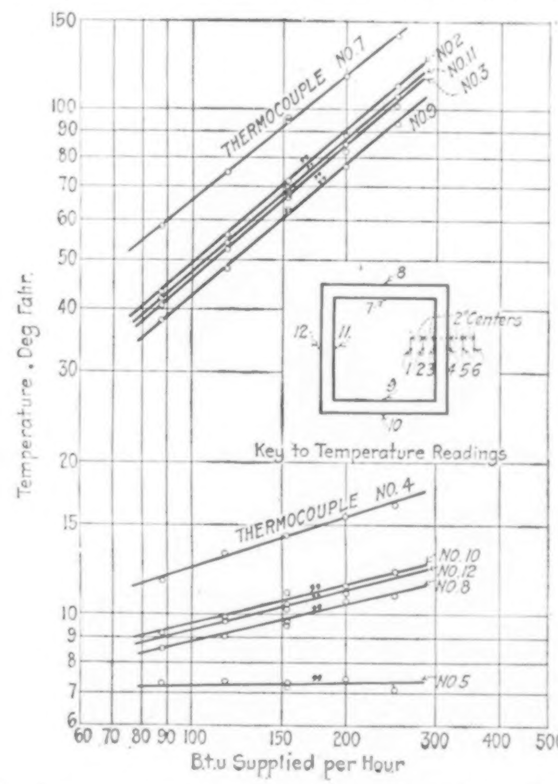


FIG. 4 TEMPERATURE READINGS OBTAINED IN TEST SERIES NO. 2 ON LITH BOARD

$$H = 4C\left\{(t_7 - t_8) + (t_9 - t_{10}) + (t_{11} - t_{12}) + (t_3 - t_4) + 2\left[\frac{(t_{11} - t_{12}) + (t_3 - t_4)}{2}\right]\right\} \qquad [1]$$

where H = the heat equivalent of the electrical input per hr.

C = conductivity of the cork in B.t.u. per sq. ft. per deg. per hr.

4 = a constant = sq. ft. of internal surface per side of test box

t_3 = temperature, deg. fahr., internal surface, front side

t_4 = temperature, deg. fahr., external surface, front side

t_7 = temperature, deg. fahr., internal surface, top side

t_8 = temperature, deg. fahr., external surface, top side

t_9 = temperature, deg. fahr., internal surface, bottom side

t_{10} = temperature, deg. fahr., external surface, bottom side

t_{11} = temperature, deg. fahr., internal surface, back side

t_{12} = temperature, deg. fahr., external surface, back side

The heat transmission of the cork was calculated by dividing the heat conducted through the front surface of the test box by the temperature differences measured 2 in. from the internal and external surfaces of the front side. The heat conducted through the front surfaces was estimated from the determined value of the conductivity and the inner and outer surface temperatures of the front side.

The calculation of the conductivity of the lith board from the tests in Series 2 gave rise to two methods:

Method 1. The first method was similar to that used in the calculations for the conductivity of cork. The heat transmitted through the cork of the test box was calculated from the temperature differences of the cork surfaces and the conductivity of the cork as determined in the tests of Series 1. The heat transmitted through the cork was then subtracted from the heat equivalent of the electrical input and the difference represents the heat transmitted through the lith board from which the conductivity may be determined. The equation of this relation is as follows:

$$4C_1(t_3 - t_4) = H - 4C[(t_7 - t_8) + (t_9 - t_{10}) + (t_{11} - t_{12}) + 2k(t_{11} - t_{12})] \ldots\ldots [2]$$

where C_1 = conductivity of lith board in B.t.u. per sq. ft., per deg. per hr.

C = conductivity of cork board in B.t.u. per sq. ft. per deg., per hr. as determined from tests of Series 1

k = the proportion of the temperature difference of the sides to the temperature difference of the back surface

and all other factors have the same significance as in Eq. [1].

TABLE 1 RESULTS OF TESTS ON 3-IN. CORK BOARD, SERIES NO. 1

Test No.		1C	2C	3C	4C	5C	6C
Temperature at thermo couples, deg. fahr.	1	36.95	53.69	64.94	79.79	93.20	104.53
	2	36.68	53.97	64.04	78.53	91.84	103.93
	3	33.86	50.90	60.08	75.02	87.80	100.22
	4	8.33	12.65	11.20	14.18	17.96	20.12
	5	4.82	8.06	5.90	7.52	10.60	12.27
	6	4.86	7.70	5.54	7.07	10.40	11.93
	7	48.36	70.25	85.55	104.18	121.37	133.16
	8	5.66	9.40	8.14	10.27	14.00	16.16
	9	29.86	45.14	53.78	67.64	78.80	90.85
	10	6.56	10.40	9.23	11.30	14.90	17.39
	11	33.86	50.90	61.16	75.38	88.16	100.26
	12	6.09	10.04	8.24	10.94	14.18	16.68
B.t.u. per hr. supplied heater		70.62	100.00	136.26	166.16	197.69	226.56
Average conductivity, B.t.u. per sq. ft. per deg. fahr. per hr.		0.102	0.098	0.105	0.104	0.108	0.109
Average conductivity, B.t.u. per sq. ft. per in. thickness per 24 hr.		7.34	7.06	7.56	7.49	7.78	7.85
Average temp. of cork, deg. fahr.		21.22	32.01	36.50	45.37	53.77	61.10
Transmission,[1] B.t.u. per sq. ft. per deg. per hr.		0.082	0.084	0.088	0.089	0.093	0.096
Transmission,[1] B.t.u. per sq. ft. per deg. per 24 hr.		1.97	1.97	2.11	2.13	2.23	2.30

[1] Based on temperatures 2 in. from surface.
Density of sample, 11.8 lb. per cu. ft.

The tests of Series 1 showed that the temperature differences of the front and back sides of the test box were dissimilar. This was possibly due to slight differences in temperature at different points in the refrigerator. Therefore, in order to estimate the temperatures of the sides of the box when testing lith board, the relation between the temperatures at the back sides of the test box was determined from the tests in Series 1. From the conductivity of the lith board thus found, the heat transmitted through that surface was calculated. With this heat known, the heat transmission was calculated as in the tests of Series 1.

Method 2. The second method for calculating the conductivity of lith board was based on the theory that the conductivity of two different materials is proportional to their temperature differences when subjected to the same conditions. In order to apply this theory to the tests of Series 2, the probable temperature of the front of the test box if cork had been inserted was obtained. Since there was a difference between the external temperatures of the front and back sides of the test box in the tests of Series 1, a constant, k_2, was obtained from their proportion. Thus, the external temperature of the back side in Series 2 could be used in estimating the probable external temperature of the front side. This theory is expressed in equation form as follows:

$$C_1 = C\,\frac{(t_{11} - k_2t_{12})}{(t_3 - t_4)} \ldots\ldots [3]$$

where k_2 = a constant = the relation between the external temperature of the front and back sides obtained from the tests of Series 1

and all other factors have the same significance as in Eqs. [1] and [2].

RESULTS OF TESTS

The results of these tests are given in Tables 1 and 2. Table 1 gives the results of the tests of Series 1, which is based upon the cork-board test box, and Table 2 gives the results of the tests of Series 2, in which the removable cover of the test box was replaced by 3-in. lith board.

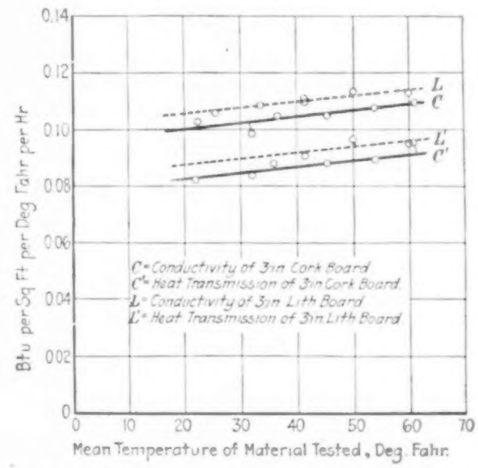


FIG. 5 CURVES SHOWING CONDUCTIVITY AND HEAT TRANSMISSION OF CORK AND LITH BOARD

The conductivity of the lith board as calculated by both methods agreed very closely. The values secured by the Method 2, however, were more consistent and were used in other calculations in preference to those determined by the Method 1. One other feature was noticeable in connection with the Method 2; namely, consistent results of the conductivity could be secured when conditions were not uniform enough to warrant the use of the Method 1. This fact was made use of in tests Nos. 4L and 3L, in which the temperature difference was small and the time that would have been required to secure uniform conditions extremely long. Since the temperatures were not absolutely constant during these tests, the heat transmissions of tests Nos. 4L and 3L were omitted as they could not be productive of representative results.

TABLE 2 RESULTS OF TESTS ON 3-IN. LITH BOARD, SERIES NO. 2

Test No.		4L	3L	2L	2XL	1L	5L
Temperature at thermocouples, deg. fahr.	1	42.89	56.84	72.81	72.73	88.93	110.92
	2	42.80	56.66	72.37	72.50	88.16	111.38
	3	40.19	53.06	67.91	67.91	84.79	103.38
	4	11.03	14.00	14.90	15.35	16.34	16.07
	5	6.80	8.24	7.88	8.60	8.24	6.71
	6	6.53	7.88	7.70	8.33	7.79	6.62
	7	57.56	75.20	96.12	95.72	116.60	138.74
	8	8.00	9.92	10.39	10.80	11.39	10.49
	9	37.22	48.56	63.20	63.33	77.18	92.21
	10	8.60	10.69	11.66	11.75	11.75	11.75
	11	41.09	54.50	69.87	69.80	84.92	105.62
	12	8.60	10.54	10.99	11.64	12.20	11.75
B.t.u. per hr. supplied heater		87.85	116.66	153.70	153.98	199.16	249.85
Conductivity, B.t.u. per deg. per sq. ft. per hr. Method 1.		.....	.....	0.112	0.118	0.126	0.109
Conductivity, B.t.u. per deg. per sq. ft. per hr. Method 2.		0.104	0.107	0.110	0.109	0.107	0.113
Conductivity, B.t.u. per deg. per in. thickness per 24 hr.		7.49	7.70	7.89	7.85	7.70	8.06
Transmission,[1] B.t.u. per sq. ft. per deg. per hr.		.....	......	0.090	0.090	0.092	0.094
Transmission,[1] B.t.u. per sq. ft. per deg. per 24 hr.		.....	......	2.17	2.16	2.21	2.26

[1] Based on temperatures 2 in. from surface.
Density of sample, 10.8 lb. per cu. ft.

The location of the thermometer elements, as indicated in the results will be understood by reference to the key to temperature

(Continued on page 654)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

SUBJECTS OF THIS MONTH'S ABSTRACTS

The Combustion Process in the Oil Engine

The Combustion Process in the Oil Engine. Discussion of the various stages constituting the combustion process in an oil engine and criticism of some of the new constructions.

The first of the stages discussed is the fuel injection. For this there are three methods available: namely, injection by compressed air, solid injection without the use of air, and injection by partial combustion in a separate chamber or retort.

As regards air injection, the influence of atomizers, needles and nozzles on the shape of the diagram has been carefully investigated and sufficient data are now available to make it possible to secure a good diagram and a smokeless combustion, no matter whether a medium-pressure, high-speed Diesel engine is desired such as was used on the submarines, or one with good regulation such as a multi-cylinder type engine used for dynamo drive. Likewise, Neumann and others have investigated the influence of the size of the droplets on the performance of the Diesel engine and the size itself has been measured and determined.

The subject of solid injection has been investigated by several concerns in Germany and engines of this kind are being built. Such injection has been used in the first place in hot-bulb engines and is satisfactory for that type. It has been extensively used, however, for Diesel engines by the Vickers concern.

The author does not appear to be in favor of the solid-injection method and gives the following comparison between solid injection and compressed-air injection as calculated for a 1700-hp. submarine-type four-stroke-cycle Diesel engine. In the case of compressed-air injection, an air-fuel volume of 75 cc. (4.57 cu. in.) has to be delivered, per cycle and injection needle, whereas in solid injection there is handled only a volume of 3 cc. (0.18 cu. in.), or one twenty-fifth that in the previous case. But, in the first place, the velocity of injection is in the neighborhood of 300 m. (984 ft.) per sec., and if with solid injection the same constant-pressure diagram is to be obtained, the same amount of fuel has to be injected at the same velocity; and the cross-section of the nozzle must also be only one twenty-fifth that of a corresponding compressed-air injection nozzle, which means that instead of the six nozzles of 2.2 mm. (0.085 in.) diameter used in air injection, there have to be six nozzles likewise used with 0.45 mm. (0.018 in.) in diameter, and in order to introduce the fuel at the same velocity as in the previous case the pressure on the fluid must be somewhere in the neighborhood of 300 atmos. The author claims that the introduction of very small volumes of fuel used makes it an extremely difficult problem to operate at such extremely high pressures.

The author further claims that the difficulties of materializing such high injection pressures are apparent in the Vickers engine in the complicated appliances used for solid injection. Thus, each of the twelve cylinders has its own fuel pump which, with its regulating devices and manometer, is as wide as the cylinder itself. If one should compare a Vickers 12-cylinder engine with a German U-boat-type four-stroke-cycle engine likewise of 1200 hp. but with six cylinders, it is easy to see how tremendously the difference in the method of injection affects the engine design; and the author fails to see in what way the elimination of an air compressor does anything to simplify the design, particularly as the use of a three- or four-stage compressor would make its operation quite simple.

The author is not aware of any published indicator diagrams of any precision covering the operation of solid-injection engines except the diagrams which appeared in *The Engineer* for Nov. 14, 1919, and apply to a submarine-type Vickers engine. The

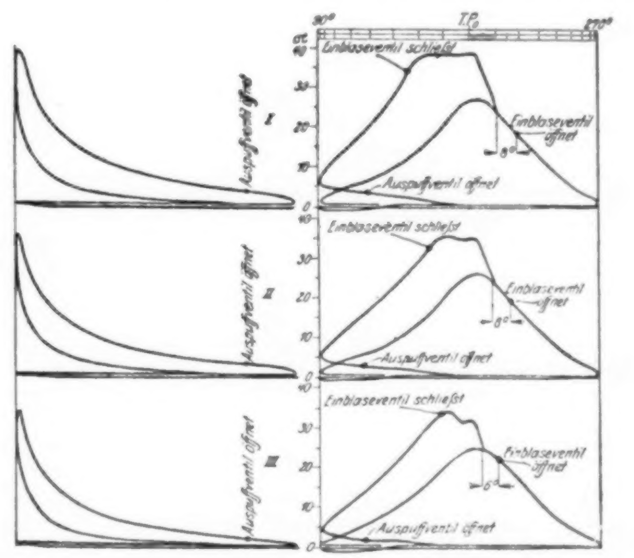


Fig. 1 Indicator Diagrams of a Vickers Submarine-Boat Type Engine with Solid Injection

(*Auspuffventil oeffnet*, exhaust valve opens; *Einblaseventil schliest*, inlet valve closes; *Einblaseventil oeffnet*, inlet valve opens; *Auspuffventil oeffnet*, exhaust valve opens; *at*, atmospheres; *TP*, dead center.)

author compares these diagrams with similar diagrams obtained from a 1700-hp. U-boat engine built at the Germania Works in Germany. His criticism of the Vickers diagram (Fig. 1) is of interest.

Table 1 Data Referring to Diagrams in Fig. 1

Diagram No.	R.p.m., n	Pressure, Kg. per Sq Cm. p_i	Output, I.hp.	Fuel-Injection Pressure, Kg. per Sq. Cm.	Fuel-Injection Valve: Duration of Opening, Deg.	Fuel-Injection Valve: Begining of Opening, Deg. Ahead of Dead Center	Beginning of Pressure Rise after Valve Opening: Deg.	Beginning of Pressure Rise after Valve Opening: Seconds
I	358	6.7	107	302	43	18	8	0.0037
II	312	5.4	76	175	33	16	8	0.0043
III	182	4.5	36	84	21	10	6	0.0055

The compression is set at 25 atmos. The explosive character of

the combustion is indicated by the substantial rise in pressure during the injection of the fuel. The pressure under which the fuel is introduced is in the first full-load diagram at a level somewhat exceeding 300 atmos. or just about the values computed above. Properly timed introduction or governing of fuel injection, such as one is accustomed to in compressed-air-injection engines, is out of the question here. Furthermore, the low compression cannot be used for computing the dimensions of the parts, such as baseplate, crankshaft, cylinder or cylinder cover, and therefore it is impossible to secure a low-weight engine, this being due to the fact that the compression pressure in low-compression, solid-injection engines rises to the same levels as in compressed-air-injection engines having a compression of from 30 to 33 atmos. Moreover, as is shown by the behavior of the expansion line with partial load, there is a strong after-combustion. It is difficult to understand how under these conditions the Vickers engine can secure the fuel combustion of 170 grams per hp-hr. (0.374 lb.) claimed for it by the makers—all the more so as apparently smokeless combustion is not secured. In proof of this latter statement, the

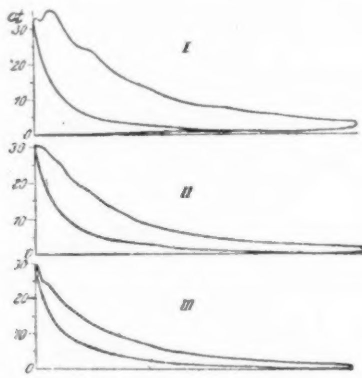


Fig. 2 Indicator Diagrams of a 1700-hp. U-Boat 4-Stroke Cycle Engine of the German Germaniawerft

author quotes the following passage from an article by an English submarine-boat officer (*Motorship and Motorboat*, 1919, p. 175).[1] "They (meaning the Vickers engine) have, however, an important disadvantage, namely, they develop clouds of smoke which stretch for miles behind the submarine. The engines also *vibrate*, no matter how carefully they may be adjusted, and if the personnel in the engine room is not very careful, they may easily produce a smoke-screen effect."

For purposes of comparison, indicator diagrams are reproduced in Fig. 2 which were taken under approximately the same conditions in respect to speed in revolutions and average compression from a 1700-hp. German U-boat engine with compressed-air injection. Here, apparently, explosive combustion and the sudden pressure rise which accompanies it are completely eliminated, and the after-burning effect is comparatively slight.

The author comes to the conclusion that solid injection is suitable only for engines with a comparatively small output per cylinder

Table 2 Data Referring to Diagrams in Fig. 2

Diagram No.	R.p.m., n	Pressure, Kg. per Sq. Cm. p_i	Output I.hp.	Fuel-Injection Pressure, Kg. per Sq. Cm.
I.............	377.6	8	431	85
II.............	295.8	5.3	179	55
III.............	239	3.5	109	45

and operating at fairly constant speed and load. For high-efficiency engines of large output, the solid-injection process must be considerably improved before it can enter into competition with compressed-air injection, and even then it is claimed by the author to have no advantage as compared with the Steinbecker process, which also operates without a compressor.

The main features of this process have already been described. Essentially, it consists of the following: A fuel pump located in the cylinder cover injects the fuel into a special passage about 3 deg. before dead center. A part of the fuel together with air

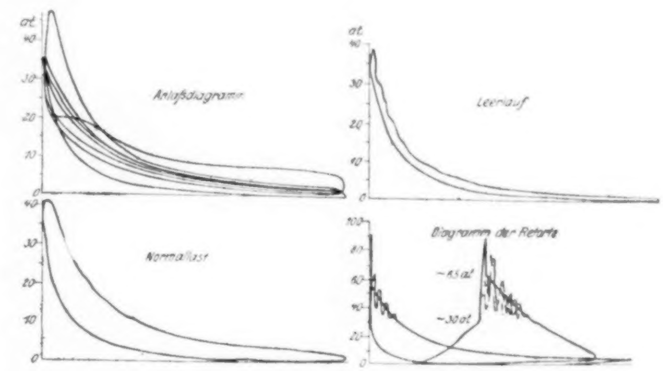


Fig. 3 Indicator Diagrams of an Experimental Steinbecker Diesel Engine

(*Anlassdiagram*, starting curve; *Normallast*, normal load; *Leerlauf*, idling; *Diagram der Retorte*, indicator diagram for the "retort;" *at*, atmospheres.)

enters a special chamber or retort filled with highly preheated air having a pressure of 30 atmos., which is several atmospheres below the compression pressure and is ignited there so that the pressure reaches 65 atmos. This pressure rise in the retort produces a powerful injection of the fuel into the main cylinder, and it is claimed that the action of this case is better than with solid injection, and the compression as good as with compressed-air injection, while the elimination of the compressor, the fuel-injection valve and the injection compressed-air tank with its valves and accessories are of course of material benefit.

In Fig. 3 are given four diagrams taken on an experimental engine of the Steinbecker type. It is claimed that the combustion was smokeless throughout.

The rest of the article discusses the subjects of vaporization, ignition, and combustion. These may be abstracted in an early issue. (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 64, no. 33, Aug. 14, 1920, pp. 637–643, 13 figs., *tc*)

Heat Transfer in Flues

Heat Transfer in Flues, Lawford H. Fry, Mem.Am.Soc.M.E. Discussion of the laws governing heat transfer in flues, with particular application to locomotive-boiler flues.

The present article is an extension of a former article by the author in *Engineering* for Feb. 19, 1909, and a paper read before The American Society of Mechanical Engineers in 1917 (Trans.Am.Soc.M.E., vol. 39, p. 709), and is based on recent work of the author and others.

The rate of heat transfer is studied in its relation to the various factors on which it depends. These factors are:

1. *Temperature.* The rate of heat transfer depends on the ratio of the temperature of the gas to the temperature of the flue wall. If the flue wall has a mean temperature t, and if the mean gas temperature at one section of the flue is T_1 and at another section x ft. distant along the flue is T_2, all temperatures being measured from absolute zero in any scale, the relation between the two gas temperatures is given by the equation:

$$\text{lolog } T_1/t - \text{lolog } T_2/t = Mx \qquad [1]$$

where "lolog" means "the logarithm of the logarithm," and where M is a constant for a given set of conditions, being determined by the dimensions of the flue and by the rate of gas flow.

2. *Flue Dimensions.* The two dimensions on which the above constant M (and hence the rate of heat transfer) depends, are the perimeter and the mean hydraulic depth. The mean hydraulic depth is the area divided by the perimeter, and in a circular flue

[1] Passage retranslated into English from the German, as the original publication is not available.—Editor.

is one-fourth of the diameter. When circular flues only are under consideration it is simpler and equally accurate to speak of the effect of the flue diameter instead of the effect of the mean hydraulic depth. This will be done in the present article, the symbol d being used to represent the flue diameter in inches. If the equations thus established are to be applied to annular or other non-circular flues, it is only necessary to replace d by $4h$, where h is the mean hydraulic depth.

3. *Rate of Flow of Gas.* The effect of the rate of gas flow on the rate of heat transfer is dependent on the weight of gas flowing per hour per inch of flue perimeter. Expressed in symbols this statement is to the effect that the coefficient M in Equation [1] varies with the ratio W/p, where W is the weight of gas flowing in pounds per hour and p is the flue perimeter in inches.

The relation between the flue dimensions, the rate of gas flow and the coefficient M is that given by the following equations:

$$\log M = B - m \log W/p \qquad [2]$$

where

$$\log (B + 1.3) = \bar{1}.71 - 0.54 \log d \qquad [3a]$$

and

$$\log m = \bar{1}.36 + 0.37 \log d \qquad [3b]$$

The derivation of these equations from the experimental data is discussed below, but attention is first directed to the conditions of heat transfer disclosed by the formulæ.

Equations [2], [3a] and [3b] show that for a given flue with gas flowing at a constant rate, the coefficient M in Equation [1] is a constant. This means that if distances along the flue x are measured from a point at which the gas temperature is T, the gas temperature T_1 at any other point is given by equation:

$$\text{lolog } T/t = \text{lolog } T_1/t - Mx \qquad [1a]$$

This is to say, the logarithm of the logarithm of the ratio of gas temperature to flue temperature (lolog T/t) falls by a straight-line law along the flue. The slope of the line giving this fall of the lolog of the temperature ratio is measured by the coefficient M.

This equation enables determining the heat transfer from gas to flue in any section of the flue by finding the temperature loss of the gas.

Furthermore, the form of Equation [1a] indicates that a large value of M corresponds to a rapid drop of temperature along the flue, that is, a rapid rate of heat transfer.

Table 1 shows how the value of M is affected by the three factors

TABLE 1 VALUE OF COEFFICIENT M FOR VARIOUS FLUE DIAMETERS AND RATES OF GAS FLOW

	Values of W				
In.	100 Lb./Hr.	200 Lb./Hr.	400 Lb./Hr.	800 Lb./Hr.	1600 Lb./Hr.
0.5	0.133	0.117	0.104	0.092	0.081
1.0	0.074	0.063	0.054	0.046	0.039
2.0	0.050	0.040	0.033	0.027	0.022
4.0	0.040	0.030	0.023	0.018	0.014
8.0	0.037	0.026	0.019	0.013	0.009

on which it depends, namely, flue diameter, flue perimeter and rate of gas flow. Another table (Table 2) in the original article is given to show the length of flue necessary to reduce the gas temperature from an initial value of 2000 deg. to 720 deg. fahr. with a flue-wall temperature of 380 deg. and from this table it appears that with a 1/2-in. flue the above temperature drop will take place in 3.76 ft. of pipe with a flow of 100 lb. per hour, while a length of 6.15 ft. will be required for the same temperature drop with a flow of 1600 lb. per hour. This is particularly significant as in the first instance the heat transferred from gas to flue is equal to 41,800 B.t.u. per hour, while in the second case the rate of heat transfer will be 16 times as great, or 668,800 B.t.u. per hour.

From the data given in Table 1 it would appear that the rate of heat transfer falls off rapidly as the flue diameter is increased. Other tables are given showing the temperature drop and the amount of heat transferred in flues 5 ft. long when the flue diameter and rate of gas flow are varied. These tables show clearly the effect of increasing flue diameter on increasing the final temperature, that is, on reducing the amount of heat transfer, while the other tables illustrate the effect on the heat transfer of varying the flue length, flue diameter, rate of gas flow and the gas temperature as well as the temperature of the flue wall.

In order to facilitate the use of the formulæ Tables 2 and 3

TABLE 2 VALUES OF COEFFICIENTS m AND B FOR FLUES OF VARIOUS DIAMETERS

d In.	B	m	d In.	B	m
0.38	$\bar{1}.561$	0.160	1.50	$\bar{1}.112$	0.266
0.44	$\bar{1}.500$	0.169	2.0	$\bar{1}.053$	0.296
0.50	$\bar{1}.444$	0.178	2.25	$\bar{1}.031$	0.309
0.58	$\bar{1}.388$	0.188	2.5	$\bar{1}.013$	0.321
0.66	$\bar{1}.341$	0.197	3.0	$\bar{2}.983$	0.342
0.75	$\bar{1}.300$	0.208	3.5	$\bar{2}.961$	0.364
0.87	$\bar{1}.253$	0.218	4.0	$\bar{2}.943$	0.382
1.00	$\bar{1}.213$	0.229	5.0	$\bar{2}.915$	0.415
1.15	$\bar{1}.175$	0.242	6.0	$\bar{2}.895$	0.445
1.30	$\bar{1}.145$	0.252	8.0	$\bar{2}.867$	0.494

are given, of which the former gives for various flue diameters the intermediate coefficients m and B which are used in establishing the coefficient M, while Table 3 gives values of the coefficient M for a number of flue diameters and rates of gas flow. The relation of m and B to the flue diameter is given by the Equations [3a] and [3b]; the values of coefficient M given in Table 3 are calculated from Equation [1], where W is the weight of gas in lb. flowing per hour and p is the flue perimeter in inches.

The data presented above were obtained by the use of methods described in the author's paper in Trans.Am.Soc.M.E., vol. 39, 1917, p. 709, in which he surveyed some of the experimental work done on heat transfer between the gas and the flue and derived experimental formulæ. As he stated, he had tried to harmonize some of the various groups of experiments without success until Hedrick and Fessenden put forward their double logarithmic (lolog) formula (Trans.Am.Soc.M.E., vol. 38, 1916, p. 407). The use of an expression of this type led to the formulæ which have been given above and which give a much wider range than any previous expressions for heat transfer.

The formulæ given by the writer are based on the experiments of Jordan, Nusselt, Josse, The Babcock & Wilcox Company, and Fessenden. In addition to these, the author analyzed five series of boiler tests, two of which were made by the Pennsylvania Railroad with locomotive boilers and the other three with stationary boilers—one by Nicolson on an experimental plug-type boiler, the second by the Bureau of Mines on a Heine boiler, and the third on a return-type boiler. (*Engineering*, vol. 110, no. 2852, Aug. 27, 1920, pp. 265–268, 5 figs., *teA*)

TABLE 3 VALUES OF COEFFICIENT M

Pounds of Gas per Inch of Perimeter per Hr.	d = Inside Diameter of Flue in Inches																	
W/p	0.38	0.44	0.50	0.58	0.66	0.75	0.87	1.00	1.15	1.30	1.50	1.75	2.00	2.25	2.50	3.00	3.50	4.00
2.00	0.326	0.281	0.246	0.215	0.1915	0.1725	0.1540	0.1390	0.1265	0.1170	0.1080	0.0986	0.0920	0.0866	0.0824	0.0758	0.0710	0.0673
2.83	0.310	0.265	0.231	0.201	0.1790	0.1603	0.1420	0.1290	0.1165	0.1075	0.0985	0.0895	0.0831	0.0780	0.0738	0.0674	0.0625	0.0589
4.00	0.292	0.250	0.217	0.188	0.1670	0.1493	0.1320	0.1190	0.1070	0.0983	0.0897	0.0811	0.0750	0.0700	0.0659	0.0598	0.0551	0.0517
5.86	0.276	0.236	0.204	0.176	0.1563	0.1390	0.1225	0.110	0.1009	0.0901	0.0818	0.0736	0.0677	0.0630	0.0590	0.0532	0.0485	0.0452
8.00	0.261	0.222	0.192	0.166	0.1460	0.1290	0.1135	0.1015	0.0903	0.0826	0.0746	0.0667	0.0611	0.0565	0.0527	0.0472	0.0427	0.0396
11.3	0.246	0.210	0.180	0.155	0.1360	0.1205	0.1053	0.0935	0.0851	0.0756	0.0680	0.0592	0.0552	0.0507	0.0472	0.0420	0.0377	0.0347
16.0	0.233	0.198	0.169	0.145	0.1270	0.1120	0.0974	0.0864	0.0763	0.0693	0.0621	0.0548	0.0498	0.0455	0.0422	0.0372	0.0332	0.0304
22.6	0.221	0.186	0.159	0.136	0.1187	0.1043	0.0903	0.0800	0.0703	0.0635	0.0566	0.0498	0.0450	0.0409	0.0378	0.0331	0.0292	0.0266
32.0	0.209	0.176	0.150	0.127	0.1110	0.0970	0.0837	0.0738	0.0645	0.0582	0.0516	0.0451	0.0405	0.0367	0.0338	0.0294	0.0258	0.0233
45.2	0.198	0.166	0.141	0.119	0.1035	0.0903	0.0776	0.0682	0.0594	0.0533	0.0471	0.0409	0.0366	0.0329	0.0303	0.0261	0.0227	0.0200
64.0	0.187	0.157	0.133	0.112	0.0965	0.0840	0.0720	0.0631	0.0546	0.0489	0.0430	0.0371	0.0329	0.0296	0.0270	0.0232	0.0200	0.0174
90.5	0.177	0.148	0.125	0.1047	0.0903	0.0781	0.0667	0.0583	0.0502	0.0448	0.0392	0.0336	0.0305	0.0265	0.0242	0.0206	0.0176	0.0159
128.0	0.167	0.139	0.117	0.0981	0.0843	0.0727	0.0618	0.0538	0.0461	0.0410	0.0357	0.0305	0.0268	0.0239	0.0217	0.0183	0.0155	0.0137
181.0	0.158	0.131	0.110	0.0918	0.0788	0.0677	0.0573	0.0498	0.0425	0.0376	0.0326	0.0276	0.0242	0.0215	0.0194	0.0162	0.0137	0.0127
256.0	0.150	0.124	0.104	0.0861	0.0736	0.0630	0.0531	0.0459	0.0390	0.0344	0.0297	0.0250	0.0219	0.0193	0.0173	0.0144	0.0120	0.0106
362.0	0.142	0.117	0.0974	0.0807	0.0688	0.0586	0.0492	0.0425	0.0359	0.0315	0.0271	0.0227	0.0198	0.0173	0.0155	0.0128	0.0106	0.0092
512.0	0.134	0.110	0.0916	0.0756	0.0642	0.0546	0.0456	0.0392	0.0329	0.0289	0.0247	0.0206	0.0178	0.0155	0.0139	0.0114	0.0094	0.0081
724.0	0.127	0.104	0.0862	0.0710	0.0601	0.0508	0.0423	0.0361	0.0303	0.0265	0.0225	0.0187	0.0161	0.0140	0.0124	0.0101	0.0082	0.0071
1024.0	0.120	0.098	0.0811	0.0665	0.0561	0.0473	0.0392	0.0334	0.0278	0.0242	0.0205	0.0169	0.0145	0.0125	0.0111	0.0090	0.0072	0.0062

Short Abstracts of the Month

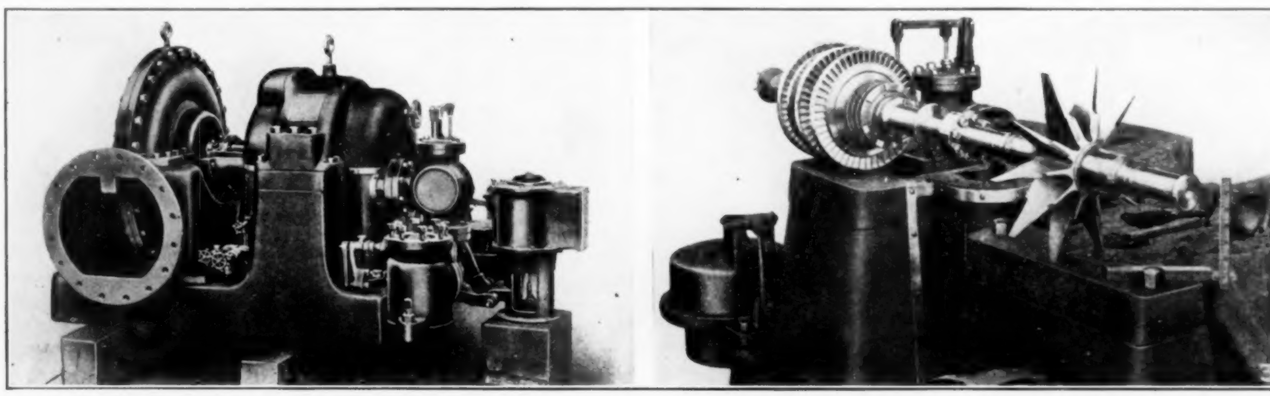
AIR MACHINERY (See Thermodynamics)

DeLaval Direct-Connected High-Speed Turbo-Blower

22,000-R.P.M. SINGLE-STAGE TURBO-BLOWER. In 1916 the Westinghouse Machine Company built a small blower designed to run at 43,000 r.p.m. which actually ran at speeds as high as 60,000 r.p.m. In one of the tests the rotor of this blower was damaged, and there is no information available whether it was ever actually placed on the market.

It has proved, however, that blowers running at these terrific speeds are fully practicable.

In this connection the unit recently built by the Rateau, Battu, Smoot Co. of New York City and described in *Power* is of particular interest. The unit was built for a South American mining concern and before shipment was operated at 26,000 r.p.m. for test purposes, but is intended for normal operation at 22,000 r.p.m. It is a single-stage turbo-blower which, when operating at its normal speed, will compress 3000 cu. ft. of free air per min. to 15 lb. per sq. in. Fig. 1 shows the complete unit assembly, with the turbine at the left.



FIGS. 1 AND 2 22,000-R.P.M. SINGLE-STAGE TURBO-BLOWER

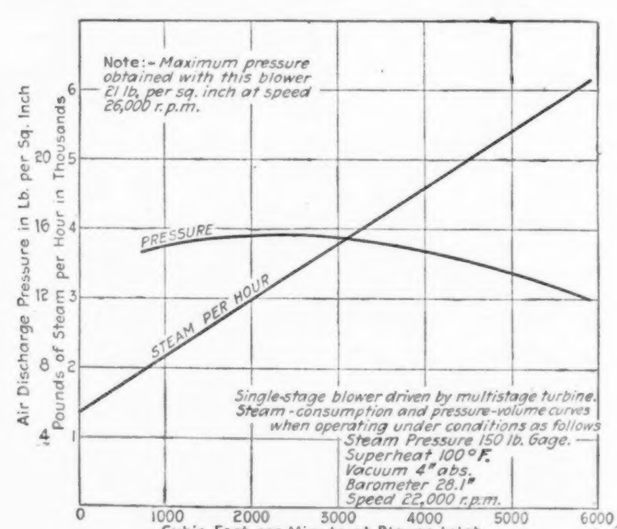


FIG. 3 PERFORMANCE CURVES OF TURBO-BLOWER OF FIG. 1

In the turbine the rotor has three wheels which are machined as an integral part of the shaft which is made of a nickel-chrome-magnesium steel, heat-treated forging, the radial blades being machined as an integral part of the shaft. Fig. 2 shows the rotor removed from the bearing and resting on the lower half of the casing. The 6-in. rule standing vertically on the right-hand end of the casing gives an idea of the size of the rotor, which weighs only 138 lb., of which 100 lb. is in the turbine rotor, and only 38 lb. in the blower rotor.

The rotor had to be made of a single piece in order to give it the maximum rigidity. It is so designed that at all points the stresses are far below the elastic limit of the metal. In machinery running at the high speeds employed in this case (at 26,000 r.p.m. the tip speed of the blower rotor is 1400 ft. per sec., or greater than the velocity of sound) centrifugal forces become of extreme importance, as one ounce weight on the end of the blade exerts a radial pull of approximately 3.75 tons.

Fig. 3 gives some data as to the normal performance of the turbine and blower as shown by the elaborate tests made before shipment. An interesting feature of the operation is that at full speed and overspeeds the machine operated without the slightest variation. The results of these tests also show that two machines of this type working in series can be made to compress air to 100 lb. pressure in small units, and three machines in series would give a compression as high or higher than 100 lb. for large-size machines. (*Power*, vol. 52, no. 9, Aug. 31, 1920, pp. 327–328, 4 figs., *d*)

BUREAU OF STANDARDS

AIR FORCES ON CIRCULAR CYLINDERS, AXES NORMAL TO THE WIND, WITH SPECIAL REFERENCE TO DYNAMICAL SIMILARITY, Hugh L. Dryden. One of the most difficult problems of the airplane designer is to obtain a method of computing forces on full-size machines or full-size machine parts from measurements made on models in a wind tunnel. A certain equation deduced from theoretical considerations has long been known and used, namely, the equation proposed a long time ago, first by Helmholtz, later stated by Reynolds, and developed more fully by Lord Rayleigh and Buckingham. This equation is a logical consequence of certain assumptions and states that, if these assumptions are true, the force of a current of air upon a solid body may be expressed as $C\rho AV^2$, ρ being the density of the air, A the area of the body projected on a plane normal to the wind, V the velocity of the wind, and C a dimensionless constant depending on a single parameter VL/ν, where ν is the kinematic viscosity of the air and L is a linear dimension of the body. This equation then implies that if C be plotted against VL/ν, the points will fall on the same curve independent of the individual value of V or L provided the bodies are geometrically similar and presented in the same manner to the wind.

This law is a logical consequence of the assumptions. Although some tests have been made of the validity of the assumptions in the case of wind-tunnel experiments, no extensive investigation of a body of simple geometrical form over a large range of values of V and L has been published. The present paper gives the results of tests on cylinders for different values of L. An attempt was made to make the assumptions involved in the derivation of the equation true as closely as is possible in wind-tunnel experiments.

Cylinders of 1, $1^1/_4$, $1^1/_2$, $1^3/_4$, 2, $2^1/_2$, 3, 4, $4^1/_2$, 5, $5^1/_2$ and 6 in.

(0.0254 to 0.1524 m.) were used at velocities from 15 to (in the case of the smaller cylinders) 80 m.p.h. (25 to 130 km. per hour, approximately). The range of values of VL/ν was from 10,000 to 185,000. The cylinders were made of wood with the exception of those less than 2 in. in diameter, which were in brass; but an additional 1-in. wood cylinder and 4-in. brass cylinder were also used. The "guard ring" principle was used to obtain results applicable to infinite cylinders.

The results show that the equation does not represent the facts of wind-tunnel experiments in the case of cylinders. The coefficient C for a 1-in. cylinder is half again as large as that for a 3-in. cylinder at the same value of VL/ν. Above a 3-in. diameter the equation is satisfied closely, the coefficient being practically constant and equal to 0.426. The curve for the 1-in. cylinder checks N.P.L. values closely. The maximum departure of any one observation from the mean is about $2^1/_2$ per cent. Measurements of the pressure distribution showed that in the case of the small cylinders the ratio of the average decrease in pressure on the back to the maximum increase in pressure on the front is greater than in the case of the large cylinders. (Abstract of *Scientific Paper of the Bureau of Standards*, no. 394, *t*)

Cast Iron for Locomotive-Cylinder Parts, C. H. Strand. Frequent removal of cylinder parts of locomotives results in greatly increased cost of maintenance to the railroads, and consequently the quality of the cast iron entering into their construction is a matter of paramount importance, particularly from the standpoint of wear. These parts include piston-valve bushings, piston-valve packing rings, piston-valve bull rings, cylinder bushings, piston packing rings and piston-head or bull rings. It was found that ordinary high-silicon cast iron gave unsatisfactory wear, particularly in modern superheater locomotives, and the tendency has been toward a harder and stronger iron.

At the request of the U. S. Railroad Administration, the Bureau of Standards has investigated the mechanical, chemical, and microscopical properties of a number of packing rings furnished with service mileage records, as well as arbitration-test bars, chill-test specimens, and miscellaneous examples from different manufacturers. All of this material was cast iron such as used for the various cylinder parts. The Bureau of Standards at the same time made a review of the previous work and specifications on the subject, to ascertain as far as possible the practices of the different foundries, and to suggest such revision of existing specifications as would be warranted by the results of the present and other investigations.

It was found that air-furnace iron is made more uniform in character and in general of somewhat better mechanical properties than cupola iron. The latter, however, often equals or even excels the air-furnace product in mechanical properties. Because of the many variable factors, it was difficult to establish correlation between laboratory and service tests. It was recommended, as a result of the present and other investigations, that the transverse-strength requirements of the Standard American Society for Testing Materials $1^1/_4$-in. Arbitration Bar be increased from 3200 to 3500 lb. for castings $^1/_2$ in. or less in thickness, and from 3500 to 3800 lb. for castings over $^1/_2$ in. in thickness. (Abstract of *Technologic Paper of the Bureau of Standards*, no. 172, *e*)

ENGINEERING MATERIALS

The Influence of Copper, Manganese and Chromium and Some of Their Combinations on the Corrosion of Iron and Steel, E. A. Richardson and L. T. Richardson. Data of experimental work made upon steel both free from and containing copper, and upon commercial pure iron both free from and containing copper.

These tests brought out a number of deductions, some of which were known before. Steel rusts much faster than iron, but the presence of iron decreases the corrosion of both—more so, however, in the case of steel. It was further found that it was the manganese present in the steel, but not in the iron, which was intensifying the action of copper in reducing corrosion.

Of considerable interest are the remarks of the authors on pure iron. Hitherto the effort was to make manganese in pure iron intended for use as a rust-resisting material as low as possible. However, commercially pure iron contains about 0.04 per cent of copper, which causes it to be red-short. The addition of a small amount of manganese would make this iron slightly more rust-resisting and at the same time remove the tendency to be red-short, while the addition of still more copper and manganese would materially increase its rust-resisting properties.

The cause of the influence of copper on the corrosion of iron has never been satisfactorily explained. The present authors propose what they call the "film" or "intergrain" theory of corrosion resistance. This theory is based on the assumption that iron only becomes rust-resistant when certain impurities are present in certain amounts. Copper creates an intergrain rust-resisting film, which, on the other hand, also assists in creating red-shortness. A brief list of references covering previous research on corrosion, and especially influence of impurities, is appended in the original article. (Paper presented at the general meeting of the *American Electrochemical Society*, Cleveland, Ohio, Sept. 30–Oct. 2, 1920, pp. 123–135, 6 figs., *tp*. Abstracted through advance copy)

20-"Year" Tests of Cement and Mortar Materials

Long-Time Tests of Portland Cement, Hydraulic Lime and Volcanic Ashes, I. Hiroi. Data of two series of tests covering a period of more than 20 years. Some of the cements used for the first series of tests were manufactured by the old process of burning in so-called "bottled" kilns, while those in the second series were produced in modern rotary kilns. Another series of tests is also under way which it is proposed to extend over a period of 100 years.

The following are some of the conclusions arrived at by the author:

In sea water neat-cement briquets attained maximum strength in the course of less than a year, after which they rapidly declined, in some cases completely losing their tensile strength in four or five years. The author ascribes this peculiarity to excessive crystallization, which makes the structure highly brittle. While losing their tensile strength almost entirely, these briquets retain their form and also show considerable amounts of compressive strength, which latter, in fact, possibly even increases while the tensile strength decreases.

Cement-sand mortar mixtures in the proportion of one part of the former to two parts of the latter in air and sea water show progressive increase of strength with age, the air curves running much higher than sea-water ones. The mean results apparently follow more or less closely hyperbolic curves (for which equations are given in the original paper), which would place the eventually attainable tensile strength of such mortar in air and sea water at 85 and 50 kg. per sq. cm. (1210 and 710 lb. per sq. in.), respectively.

Tests were also made to determine the influence of the kind of sand used for mortars, and it was found that while standard and coarse sands produced practically equal strength, fine sand was found to be decidedly inferior in air, fresh water and sea water, both in tension and in compression.

As regards the strength of mortars in sea water, it was found that the lower the proportion of sand in the mortar the stronger the latter will be.

The results, however, have also suggested the possibility that in mortars to be used in sea water an excess of cement is to be avoided as much as a deficiency. A proportion richer than 1 : 1 is too costly and one lower than 1 : 3 may have voids; the proportion of 1 : 2, on the other hand, has little more cement than is sufficient to fill up all the interstices in the sand.

Tests on the effect of curing in fresh water on the strength of mortars kept in sea water have not indicated any definite and material improvement due to curing.

An interesting series of tests was made on the use of volcanic ashes in cements, the ashes used being of Japanese origin exclusively. In air tests it was found that the greater the amount of ashes used the lower the strength of the briquets, and none of the ash-cement mortars had a strength equal to that of the straight cement ones. On the other hand, in sea-water tests the superiority was decidedly on the side of the ash-cement mortars, which are, however, weaker than straight cement mortars in compression.

The action of volcanic ashes when used in a cement mortar appears to be twofold, viz., mechanical and chemical. Mechanically, the ashes increase the density of the mixes, making the latter more or less impermeable to sea water; chemically, the combination of silica with free lime in cement, which makes the latter unassailable by the sulphates contained in sea water, seems to be the most important action. The activity of silica contained in ashes naturally depends on the state in which it is present; and while there is no doubt that the soluble portion is the most active agent, the total amount of silica should also be taken into consideration. Thus, the Otaru ashes, which according to the analysis contain the least amount of soluble silica of the three but the largest amount of the insoluble one (on an average of 61 per cent in the Otaru ashes, 47 per cent in the Yoichi, 34 per cent in the Goto), produced higher strength than either of the other two ashes. That a portion of insoluble silica enters into combination to form soluble compounds in course of time is shown by the several analyses made of (Otaru) ash-cement mortar block kept in sea water, the results of which are given in the following table:

Time of Analysis	Silica (Total 100) Soluble	Insoluble
Before induration	43.73	56.27
2 months	46.28	53.72
7 months	47.29	52.71
14 months	50.08	49.92
38 months	53.95	46.05

The value of volcanic ashes, as an ingredient in a cement mortar is possible of direct determination by testing the combining power of the ashes with lime. (*Journal of the College of Engineering, Tokyo Imperial University*, vol. 10, no. 7, 1920, pp. 155–172 and 10 plates, *e*)

FUELS AND FIRING

German Pluto Stoker and Its Improvements

DEVELOPMENT OF THE PLUTO STOKER FOR THE UTILIZATION OF LOW-GRADE FUELS, Otto Nerger. While attempts were made in Germany and Austria before the war to utilize the poorer grades of fuel, it was under the pressure of war conditions that a really earnest effort was made in this direction. Among the poorer grades of fuel available for industrial use on a large scale by the Central Powers are, first, the waste products of the coal mines, such as coal dust, breeze, products of coal washing, coke breeze

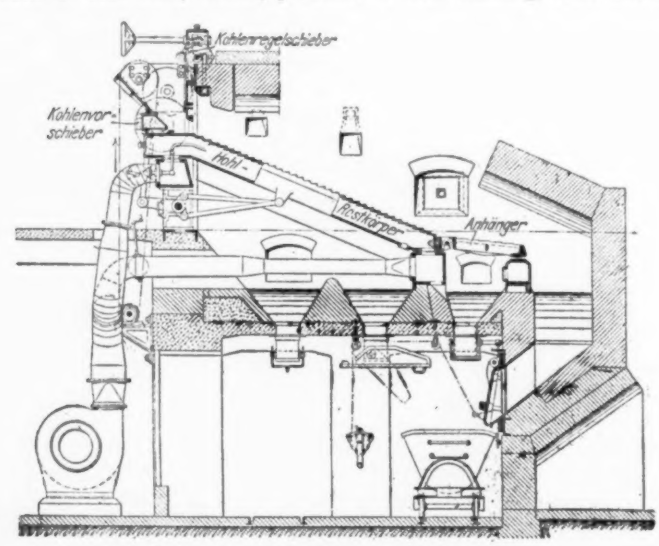


FIG. 4 EARLY DESIGN OF PLUTO STOKER

(*Kohlenregelschieber*, slide plate to govern rate of supply of coal; *Kohlenvorschieber*, slide plate to govern supply of fresh coal to fuel bed; *Hohlrostkörper*, hollow grate bars; *Anhänger*, rocking slag grate.)

and coke ashes. Next to this come such low-grade coals as lignite and peat, the latter fuel being largely in a class by itself, however.

All of these low-grade fuels require special appointments for their utilization, depending to a certain extent on the moisture and ash contents of the fuel, but above all on the content of volatile matter in the fuel, which latter ultimately determines whether the fuel can be utilized at all.

Among other things, low-grade fuels require special grates, and in Germany forced-draft traveling grates were chiefly used, while in Austria and Hungary preference was given to the so-called Pluto stoker.

A Pluto stoker of old design is shown in Fig. 4. Its chief characteristic was the use of a massive hollow grate body and rigid side walls. Early users often found that the hollow grate bars did not last very long and that the fire on them could not be well maintained. In later years, however, improvements made in the design largely eliminated this source of trouble, and it was found that some of the early troubles were due chiefly to the fact that the amount of draft available in the furnaces was entirely insufficient, which led to improper combustion and rapid deterioration of the grate bars.

It is claimed that in those early days there existed an erroneous impression that the availability of forced draft made the further and more important action of the smoke stack unnecessary, which is, however, incorrect, as the action of the forced draft can hardly be sufficient to overcome the resistance of the fuel bed and to produce a slight vacuum in the fire chamber. Even then the question of carrying off the gases of combustion without material turbulence remains still to be taken care of.

In an effort to remedy as far as possible the troubles in the hollow grate bars indicated above, an attempt was made to produce what the original article calls a "removable grate," which makes it possible to take out particularly badly attacked parts of the grate surface and to replace them by fresh elements at a comparatively low expense. Fig. 5 shows such a grate with removable bars. From this it appears that the general shape of the grate has not been changed, but that each section consists of a frame and grate elements inserted therein. This construction has also been of advantage because the bending of the massive hollow grate bars used in the older structure has disappeared in the new, and it is claimed that the new type of grate, of which many thousands were installed during the last five years, has proved to be more economical from the point of view of replacements than chain grates. This is due to the fact that in the Pluto stoker it is only the inserted elements in the firing zone that have to be replaced from time to time, while the frame and other parts are subject to practically no wear.

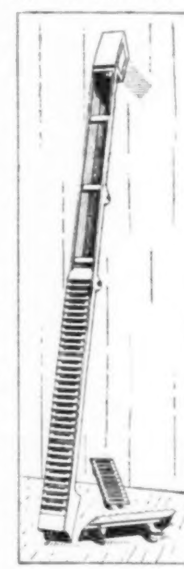


FIG. 5 PLUTO STOKER GRATE WITH REMOVABLE BARS

In order to reduce as much as possible the dropping through the grate of unconsumed combustible material, the rigid side walls of the older grate were replaced by a springy, adjustable structure such as is shown in Fig. 6. From this it would appear that the structure maintains its adjustment at all times because the springs are located not at the level of the combustion chamber, but in the comparatively cool ashpit. Furthermore, the arrangement of the parts is such that there is always an opportunity to tighten up the springs even while the furnace is being operated.

In many types of furnace it has been found that the residues of combustion clinker together on the short and rigid ash grate and can be removed only by knocking them off with bars through sidewise-located openings. This trouble has been encountered quite often, particularly with fuels inclined toward the formation of clinkering slags. To obviate this the usual rigid plane grate has been replaced by a suspended traveling grate, the construction of which may be seen in Fig. 4. This suspended grate is connected to the hollow bar grate by means of a hinge and, therefore, goes through the same motions as this latter. Because of this the slags are never at rest and have no opportunity to clinker.

Furthermore, the use of the movable suspension grate has the advantage that by the simple displacement of a rear grate support the angle of inclination of the grate may be varied, which, in its turn, varies the rate of sliding of the fuel. In the case of coals of lower ignitibility, which require a longer time for complete combustion, a very slow rate of travel may be secured by an appropriate variation in position of the suspended grate.

A further improvement as compared with the type which was at first used in Germany, consists in the use of a so-called water-column motor with worm-gear drive. This motor is attached to the boiler feed line and makes it possible to vary the rate of travel of the grate within wide limits by throttling more or less the water-admission valve. Furthermore, this type of water-column motor has no fast-moving parts and no uneconomical ratio of speed transformation. It simply transmits the up-and-down movement of the piston directly to the oscillating stoker shaft by means of a connecting rod. The water-column motor replaces not only the electrical driving motor but also transmission and governing devices. Tests made with this type of motor have shown that the duration of a double stroke of the stoker shaft can be varied at pleasure from 8 to 80 sec. by proper adjustments on the motor. The details of this motor are not shown in the original article. (*Stahl und Eisen*, vol. 40, no. 29, July 22, 1920, pp. 969–975, 8 figs. and one large table, *de*)

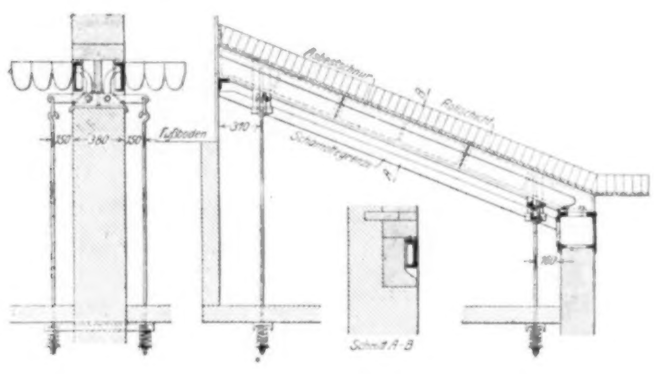


FIG. 6 THE SIDE WALLS OF A PLUTO STOKER WITH SPRING AUTOMATIC ADJUSTMENT

(*Fussboden*, floor; *Asbestosschnur*, asbestos windiag; *Schnitt A-B*, section through A-B; *Schamottengrenze*, edge of refractory clay.)

FUELS AND FIRING

FUEL-ECONOMY REPORT OF THE BRITISH ASSOCIATION. Abstract of the third report of the Committee (Prof. W. A. Bone, Chairman) appointed for the investigation of fuel economy, utilization of coal, and smoke prevention, presented to Section B at the British Association Meeting on Aug. 26. The report gives a considerable amount of data on coal mining and export statistics which cannot be abstracted here, also on future gas standards and alcohol from coke-oven gas.

As regards the gas standards, the Committee looked at the question primarily from the point of view of the national interests as a whole, and particularly from that of domestic and industrial gas consumers. It agreed with the Fuel Research Board that the future basis of charge to the consumer should be the actual number of thermal units supplied to him in the gas which passed through his meter, but desired that the charge should be based upon the "ascertained net calorific value" of the gas supplied rather than its "declared calorific value" as proposed by the Fuel Research Board.

As regards the gas pressure, the Committee recommended not less than 2 in. of water at the exit of the consumer's meter and not any measure of pressure in the mains or service pipes, taking the stand that what mattered to the consumer was the adequacy of the pressure in his pipes rather than in the gas mains outside his premises. The Committee attached great importance to the pressure being maintained as constant as possible, as well as to the requirement that greater attention than ever be paid to the removal of cyanogen and sulphur impurities from the gas.

In this connection some data are mentioned from the Gas Regulation Bill, now under consideration in the British House of Commons. Among other things, this bill introduces a new unit for the sale of gas, namely, the "therm," equal to an amount of gas containing 100,000 B.t.u.

As regards the production of alcohol from coke-oven gas, it is stated that the trials made at the Skinningrove Iron Works have demonstrated the possibility of obtaining on a large scale 1.6 gal. of absolute alcohol per ton of the Durham coal used in the tests. For data on the Skinningrove process see MECHANICAL ENGINEERING, June 1920, p. 352. (*The Engineer*, vol. 130, no. 3374, Aug. 27, 1920, pp. 196 and 198, *g*)

HYDRAULICS

FLOW OF OIL IN PIPES, Arthur C. Preston. Discussion of the flow of viscous liquids in pipes, having for its aim the development of a method for determining frictional loss as a function of the viscosity and density of the liquid. The flow of mineral oils is primarily considered, but the method is general and may be applied to other fluids. The author claims that the rate of flow of liquid moving through a pipe under a gravity head is influenced by three characteristics of the liquid itself: namely, the density which supplies the pressure-producing flow, the viscosity which retards flow, and inertia, which, under certain conditions, manifests itself in the dissipation of energy by the collision of eddying particles. These three constitute what may be called the internal group of factors affecting flow, while such factors as diameter, length, and roughness of the pipe and the amount of gravity head are external factors and secondary in the order of consideration of the problem as a whole.

Hydraulic tables are claimed to be incapable of furnishing a satisfactory basis for estimating the flow of one liquid when the flow of another has been determined by the same pipe. On the other hand, when a general solution for the problem of liquid flow is obtained, it takes the place of hydraulic formulæ and gives the same results simply by substituting in the general formulæ the physical dimensions of the pipe and the values for the particular density and viscosity of the liquid flowing, such as water.

The first part of the article, which is all that has been published so far, is devoted to a discussion of the questions dealing with the viscosity of the liquid. One of the conclusions to which the author comes is that liquids of equal Saybolt viscosity have equal pipe-friction losses, at least through the range of velocity in which flow is steady and also for all higher velocities. (*Chemical and Metallurgical Engineering*, vol. 23, no. 13, Sept. 29, 1920, pp. 607–612, 3 figs., *tA*)

MACHINE TOOLS

Sonic Wave-Power Tools

DORMAN WAVE-POWER TOOLS. In MECHANICAL ENGINEERING, June 1920, p. 359, an abstract was given dealing with the Constantinesco sonic waves and the method of power transmission by rapid impulses in liquids.

Information about this novel method has been scarce and not easily obtainable. The method itself was invented by George Constantinesco, a Roumanian engineer, and was in the early stages of development in England when the world war broke out. As soon as this happened the British government took over the experimental work and made the patents secret under the Defense of the Realm Act. This secrecy was maintained to such an extent that even Walter Haddon, a prominent British manufacturer and associate of the inventor, was forbidden access to his own works, W. H. Dorman & Co., Ltd., and refused information regarding results obtained.

The necessity of such secrecy was due to the fact that the wave-transmission method was early applied to the C.C. gear for the automatic firing of guns on aeroplanes.

Since the close of hostilities, W. H. Dorman & Co., Ltd., restored to the use of their patents, have been at work in the development of power transmission by wave motion and the tools necessary for its application. The following information is obtained

from a publication issued by the company, under the title Dorman Wave Power Tools, this source of information being used in this case because of the fact that no other source is available. For the principles of the method, reference is made to the abstract in the June issue of MECHANICAL ENGINEERING referred to in the first paragraph.

The wave-transmission installation consists of three units corresponding to dynamo, transmission line and motor in electrical installations. The first of these units is a wave generator, which consists of one or more metal cylinders, each fitted with a piston connected by a crankshaft to some high-speed prime mover such as a steam or internal-combustion engine, or, considered for this particular purpose, an electric motor; second, a wave-transmission pipe line which may be either rigid or flexible and in which various kinds of fluids may be used, though the highest transmission efficiency is obtained with water; third, a wave motor, which consists of one or more metal cylinders, each fitted with a piston designed to receive the power wave at the intake end, the other end of the piston being suitably connected to the tool or mechanism desired to be operated. The simplest application is found in such appliances as rock drills and riveting hammers, where the piston is used as a floating hammer and strikes directly on to the shank end of the drill or rivet snap.

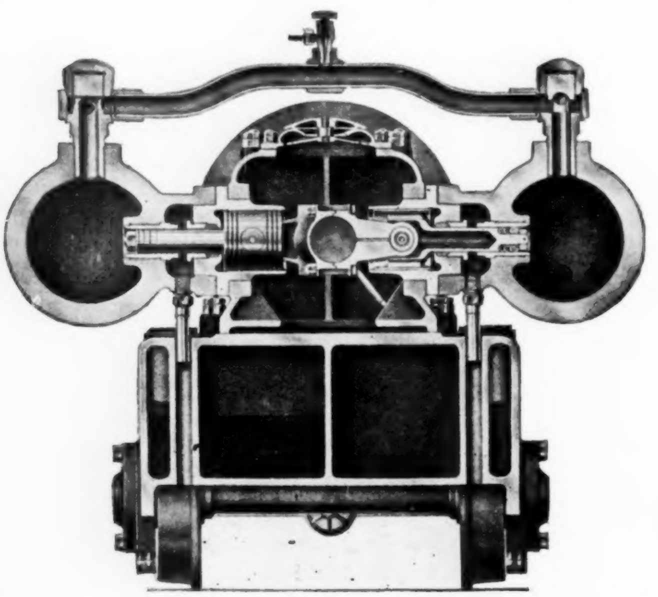


FIG. 7 WAVE POWER-TRANSMISSION GENERATOR (SECTION THROUGH "CAPACITIES")

Essentially, a wave generator is a pump, but since its purpose is not so much to convey the liquid as to convey it in a certain manner, that is, by impulses regularly following each other at predetermined intervals, it has some features not encountered in ordinary pumps. One of these is the so-called "Capacity," shown in Fig. 7. By "Capacity" in wave-transmission terminology is meant two spherical hollow steel castings designed to suit the pressures adopted. These are bolted to the crankcase and located by the crosshead guide. The disposition of these vessels on either side of the crankcase balances the forces of the crankshaft and insures freedom from vibration and quiet running at high speeds. The vessels are connected by a pipe at the top, the function of which is to equalize the pressure in each and enable the whole energy of the generator to be taken from either vessel. At the highest point of the balance pipe is a small needle valve for releasing any air which may get into the system. This is only required for a few seconds when starting up.

Screwed into the left-hand spherical vessel is an inlet charging valve actuated by pressure difference. When the minimum pressure in the capacity is greater than the pressure of the pump, it is closed. But immediately upon the pressure in the capacity being lower than the pump pressure (due to loss of water) it opens.

For the pipe line either rigid or flexible piping may be used. The construction of the Dorman flexible pipe is shown in Fig. 8. The individual sections are made from solid-drawn steel tube or other metal, with spherical joints at the ends. These joints consist of a piece of steel formed with a spherical recess at each end, into which fits a length of solid-drawn tube upon which is mounted a ball piece which accurately fills the spherical recess. The ball piece is flattened out on one end to receive the special packing ring made from materials suitable for the purpose for which the pipe is used.

A spherically seated nut screwed into the double socket shoulders against the spherical surface of the ball piece and holds the pipe together. It is claimed that this type of piping can be made for pressures up to 10 tons per sq. in. and also that it has been in constant use for the last three years under alternating pressure varying from about 1600 lb. per sq. in. down to atmospheric pressure,

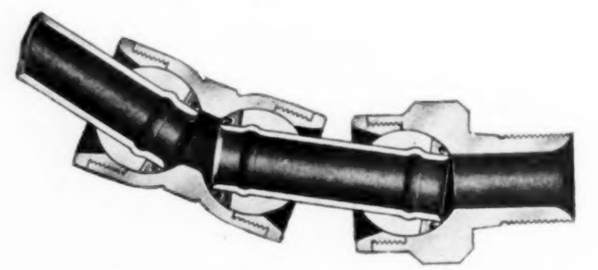


FIG. 8 DORMAN FLEXIBLE STEEL PIPE

the pressure variations taking place between these two extremeties forty times per second without causing the slightest trouble.

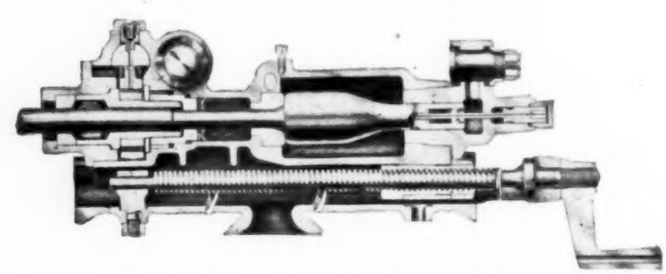


FIG. 9 WAVE POWER-TRANSMISSION HAMMER-TYPE ROCK DRILL

The third element in the wave power-transmission system is the motor, but this is not shown in detail in the publication from which the present abstract is taken. The illustration in Fig. 9, however, will give an idea of the construction of wave-power tools, such as hammer-type rock drills. In this connection, it may be stated that for this type of hammer a rapidity of 2400 to 3000 blows per minute is claimed, which, it is said, gives a higher rate of penetration at a lower power consumption than is possible with the pneumatic drill. (*Dorman Wave Power Tools*, published by W. H. Dorman & Co., Ltd., Stafford, England, 68 pp., illustrated, *d*)

MINING MACHINERY (See Machine Tools)

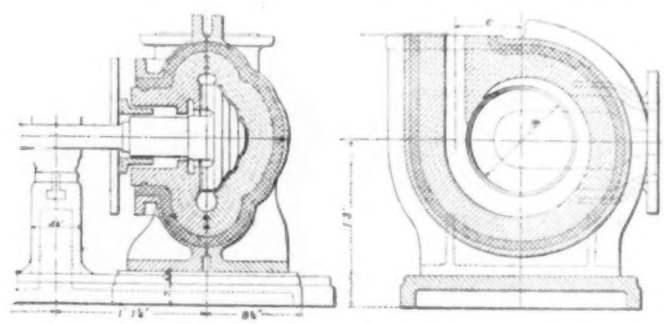
PUMPS

PUMPS FOR CORROSIVE LIQUIDS. The question of pumps for corrosive liquids is of particular, though not exclusive, interest to the chemical industry. Various materials have been tried which, while satisfactory for some purposes, failed under other conditions. Thus, ferrosilicon resists some acids but not hydrochloric acid, and is unsuitable for processes where contamination with iron must be avoided. Lead and regulus metal cannot be used for solutions containing metallic salts. Ebonite will not withstand hot liquids and is attacked by some chemicals.

It would appear that the substance which is most generally suitable for resisting the action of corrosive liquids is some kind of silicious ceramic material, as this can be obtained in forms entirely insoluble in almost any liquid. On the other hand, however, the usual type of ceramic material is difficult to shape and has somewhat unsatisfactory mechanical properties.

During the war, however, a new ware was developed under the necessity of finding some substance suitable for apparatus for condensation of large quantities of acid gas. Like silica ware, it can be plunged when red hot into cold water without cracking and has also good heat conductivity. This material was known as "ceratherm." Since the war a modified form of this material was adopted by Guthrie & Co. of Accrington, England, in the manufacture of their acid-proof pumps. This modified ceratherm material can be manufactured to accurate dimensions with greater ease than the original material.

The design of ceratherm pumps will be understood from Figs. 10 and 11. The acid-proof material forming the body of the pump is very thick and strong and is cemented into an iron casing. It is so arranged that it is only subjected by the bolts to crushing stress. The gland through which the plunger passes is usually on the section side, so that it is relieved from pressure, and the stuffing box is



Figs. 10 and 11 Ceratherm Pump for Corrosive Liquids

packed with a small quantity of wool, usually soaked in paraffin wax.

The pumps are built mainly in small sizes to lift, say, from 20 to 100 gal. per min. against a head up to 120 lb., although pumps have been built for a head of 300 lb. and larger sizes have been made. (*Engineering*, vol. 110, no. 2851, Aug. 20, 1920, pp. 253–254, 6 figs., *d*)

Roto-Piston Vacuum and Pressure Pumps. In these pumps the motions are produced by two cylinders, one, the Roto-piston, being enclosed in the other and touching it at only one point as they are mounted on different axes (Fig. 12). The inner is revolved at the same angular speed as the outer by cranks connecting the two cylinder heads. The throw of the cranks is such as to allow

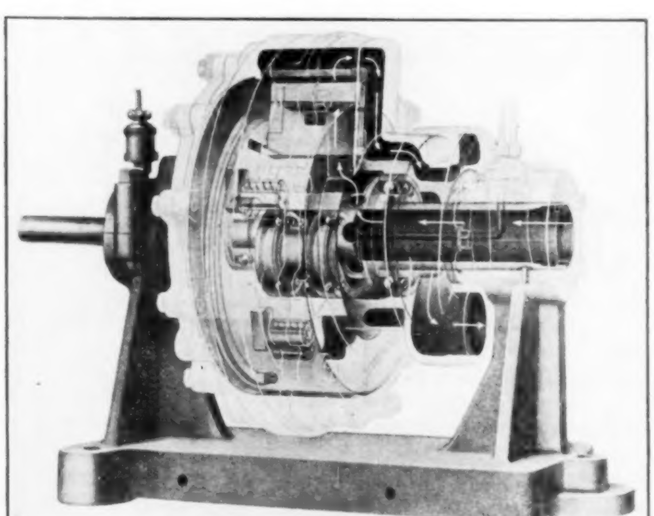


Fig. 12 Roto-Piston Pump

the Roto-piston pump to maintain contact with the outer case in an apparently eccentric motion which is, nevertheless, completely balanced. The crescent-shaped space between the cylinders is sealed at its ends by the contact of the cylinders and at any point by a vane which slides in the Roto piston and maintains contact with the outer cylinder.

As the crescent chamber remains fixed in revolution the cylinders roll past it and the vane moves through with them, displacing the space as positively as in a reciprocating pump although the motion is rotary and continuous. It has a sliding area of a little over 1 in. on the outer case. The main shaft remains stationary during revolution. There are no valves and the pump is air cooled. The pumps are made in both pressure and vacuum types. (*Iron Age*, vol. 106, no. 7, Aug. 12, 1920, p. 393, 1 fig., *d*. The illustration used in Fig. 12 was obtained through the courtesy of the Crescent Sales and Engineering Co., Detroit, Mich.)

RAILROAD ENGINEERING (See Thermodynamics)

REFRIGERATION (See Thermodynamics)

SPECIAL MACHINERY (See Machine Tools)

British Machine for Testing Springs by Scragging

Spring-Scragging Machine. Description of a new type of spring-scragging machine recently designed by Samuel Denison and Son, Hunslet Foundry, Leeds, England.

The ordinary scragging test applied to springs consists, in the case of laminated springs, of flattening the camber, or, in the case of springs having no camber, of giving the spring a slight deflection. Helical or volute springs are tested by closing them down hard.

The system adopted in the new machine, Fig. 13, embodies a motor-driven variable-speed rotary oil pump on the Hele-Shaw principle. The scragging gear is virtually a vertical press with a horizontal table or anvil and a vertical inverted cylinder directly overhead.

The energy put into the spring on the down stroke serves to return the tup to its normal position without the use of the pump. Owing to the piston rod on the under surface of the piston, the effective cylinder volumes on the two sides differ. In order to get rid of the surplus oil on the upper side of the piston on the up stroke, therefore, it is bypassed back to the replenishing tank by means of a shuttle valve in the pipe service connecting the top of the cylinder and pump. This valve operates the bypass as soon as the pump is put in the neutral position. While the tup is moving up the underside of the piston is supplied with oil by suction, some of the oil from the top side of the piston being bypassed to the underside for this purpose.

It is possible with this arrangement to obtain about 40 complete strokes of the tup per minute. For this a large pump unit is necessary. In order to assist in rapidly controlling this a small relay pump is introduced into the system as shown in the illustrations. The latter pump is controlled by the operator by means of a lever, to be seen in Fig. 13, and hunting gear to the main pump control, the main pump cutting out the small pump as soon as its work is accomplished. The effort needed to set the small pump in operation is very small, as also is the hand movement necessary to secure the up and down strokes of the tup. (*Engineering*, vol. 110, no. 2851, Aug. 20, 1920, pp. 243–244, and an illustration on p. 242, *d*)

THERMODYNAMICS

Shape of Insulation and Efficiency of Heat Transfer

The Effect of Geometric Form upon the Heat Transfer through Insulation, C. E. Rose. The author investigates the methods for the selection of insulation for various uses: in particular, the relation between the shape of the insulating element to its efficiency as an insulator. This has a particular value for the refrigeration industry. In such applications as the insulation of steam piping, it is of course also desirable to make the insulating element as efficient as possible, but not so important as in refrigeration, because heat is much cheaper to produce than cold and therefore its loss is less important. The writer analyzes three cases, of which the first is quite common, while the other two, as he claims, have not been properly investigated.

The first case is that of cork board used for insulation with the

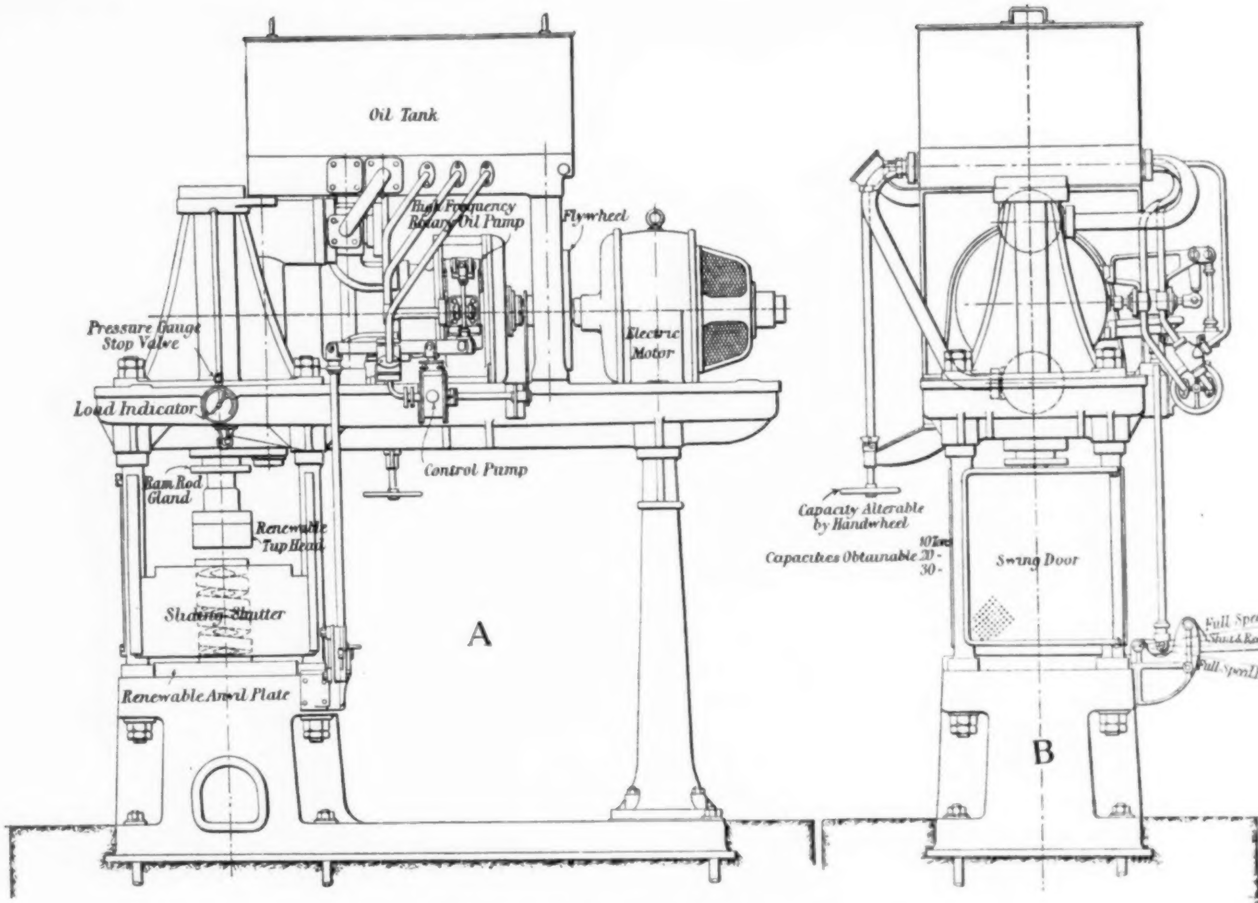


FIG. 13 NEW SPRING-SCRAGGING MACHINE OPERATING AS A PRESS

heat transfer occurring normally to its largest area. The second case is that of circular pipe insulated with a cylinder of insulation (Fig. 14). For this case the writer derives an expression

$$Q = C\frac{(1/R_1)(T_2 - T_1)}{\log_e R_2 - \log_e R_1} = \frac{C(T_2 - T_1)}{R_1 \log_e (R_2/R_1)} \ldots\ldots\ldots [3]$$

where Q is lb-deg. fahr. units transferred per sq. ft. of pipe surface per hour; C is a laboratory constant of heat transfer which has to be determined for each material; R_1 is the radius of pipe in inches; R_2 outside radius of insulation; T_1 temperature in deg. fahr., low side of insulation; T_2 temperature in deg. fahr., high side of insulation.

The expression

$$Q_1 = \frac{2\pi C(T_2 - T_1)}{\log_e (R_2/R_1)} \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

gives the rate of absorption for cold piping or radiation for hot piping.

If the rate of heat transfer is known and the thickness of insulation $R_1 - R_2$ must be calculated, the formula

$$R_2 = R_1 e^{\frac{C(T_2 - T_1)}{R_1 Q}} \ldots\ldots\ldots\ldots\ldots [5]$$

may be used, where e is the Naperian base.

Case 3 is that of a circular pipe enclosed in a square of insulation (Fig. 15), such as a pipe laid in a box or trench filled with granulated cork, the pipe being installed coaxially with the trench.

For this the author derives the following formulæ for the heat transfer:

$$Q_2 = C\frac{4}{\pi}\frac{R_2}{R_a}\left[\frac{(T_2 - T_1)}{R_1 \log_e (R_a/R_1)}\right] \ldots\ldots\ldots\ldots [7]$$

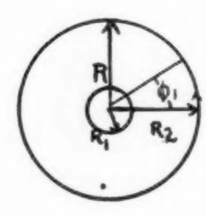
lb-deg. fahr. units per sq. ft. of pipe surface per hour, and

$$Q_2 = 8C\frac{R_2}{R_a}\left[\frac{(T_2 - T_1)}{\log_e (R_a/R_1)}\right] \ldots\ldots\ldots\ldots [8]$$

lb-deg. fahr. units per linear foot of pipe per hour, where R_2 is the mean integrated radius vector.

The writer takes numerical examples, one for each case, and ascertains what results the changes of form have upon the rate of heat transfer in unit time at constant thickness through 2 in. of formed cork having a heat-transfer constant $C = 0.49$ lb-deg. fahr. units per sq. ft. per deg. difference per in. of thickness per hour and a temperature difference of 100 deg. fahr. $= T_2 - T_1$.

The actual calculations are given in the article. In case 2, a 2-in. molded cork insulation is applied to a 2-in. pipe, in which case Equation [3] gives $Q = 37.8$ lb.-deg. fahr. units per sq. ft. per hr.



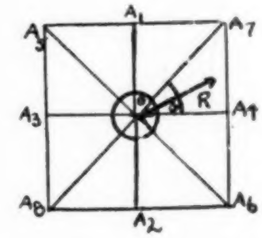


FIG. 14 CIRCULAR PIPE INSULATED WITH A CYLINDER OF INSULATION (DIAGRAMMATIC)

FIG. 15 CIRCULAR PIPE ENCLOSED IN A SQUARE OF INSULATION SUCH AS BOX OR TRENCH (DIAGRAMMATIC)

A similar computation for the case of cork-board insulation and heat transfer normal to its largest area gives for Q a value of 24.5 lb.-deg. fahr. units per sq. ft. per hr., whereas in case 3, with $R_1 = 1$ in. and a thickness of covering at A_4 of 2 in., gives 27.6 lb-deg. fahr. units per average sq. ft. per hr.

It would appear, therefore, that the second form transmits 54 per cent and the third form 11 per cent more heat (at the particular thickness of 2 in. with 2-in. pipes) than the first form. (*Ice and Refrigeration*, vol. 59, no. 3, September 1920, pp 82–84, 4 figs., *tp*)

Wire-Drawing Compression Method of Heating Gases —Causes of Overheating in Air Compressors with Leaky Delivery Valves

A Dynamical Method for Raising Gases to a High Temperature, Prof. W. H. Watkinson. If air be allowed to flow from the atmosphere through a spring-loaded wire-drawing valve adjusted so that the air in the cylinder during the charging stroke is constantly at a pressure of one-quarter of an atmosphere and if this air is subsequently compressed to atmospheric pressure, then, assuming adiabatic and frictionless conditions and neglecting the effect of clearance in the pump cylinder, the absolute temperature of this air at the end of compression will be approximately $1^1/_2$ times the absolute temperature of the outside atmosphere; that is, T_c, Fig. 16, will be approximately equal to $1^1/_2$ times 288, that is, 432 deg., when the atmospheric temperature is 15 deg. cent. The reason for this is that the constant-pressure line $a\,b$, Fig. 16, is approximately an isothermal line for the varying mass of air in the pump cylinder, and the temperature of the air during the charging stroke is approximately the same as that of the outside atmosphere.

From the equations giving the connection between temperature, pressure and volume of a given mass of gases undergoing expansion and compression, namely,

$$\frac{T_c}{T_b} = \left(\frac{p_c}{p_b}\right)^{\frac{n-1}{n}} = \left(\frac{V_b}{V_c}\right)^{n-1}$$

it is obvious that the absolute-temperature ratio depends on the absolute-pressure ratio and not on the magnitudes of these pressures. If in the above illustration the air had flowed into the cylinder at a pressure of 25 atmos. from a receiver in which the air was at a pressure of 100 atmos. and at a temperature of 15 deg. cent., the temperature of the air after compression in the pump to 100 atmos. would have been 432 deg. abs., i.e., the same as in the above case. Therefore, if a pump arranged as shown in Fig. 17 is used and air from the atmosphere is admitted to the pump cylinder b by means of the wire-drawing valve d, and this air after compression is discharged through the valve e into a receiver f, its temperature within this receiver will be 432 deg. abs.

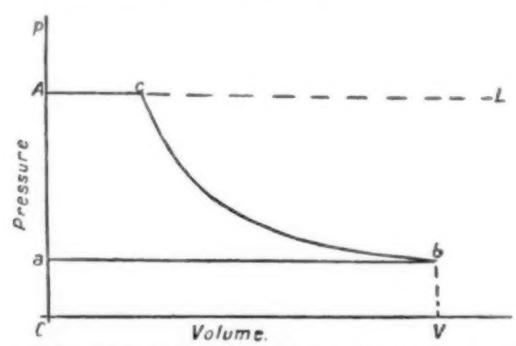


Fig. 16 Pressure-Volume Diagram for Compression with Wire-Drawing Valve

If this air is then admitted to the other end of the cylinder and is wire-drawn during admission, by the valve g, to one-quarter of an atmosphere, and then compressed to atmospheric pressure and discharged through the valve h, the temperature of the air in the pipe i will be $288 \times 1.5^2 = 648$ deg. abs. and its pressure there will be atmospheric.

With five such double-acting pumps in series, the temperature of the air leaving the last pump at atmospheric pressure would be 16,600 deg. abs., providing the process could be carried out under the conditions assumed for the first stage. Actually, the temperature of the air leaving the second pump would be approximately 4600 deg. abs., and with our present materials and present types of compressors this is probably the upper limit at which the pump could be made to operate. Furthermore, to obtain the enormous increase of temperature stated above by single-stage compression would require the pressure ratio to be about 1,040,000, so that if the initial pressure was at one atmosphere the final would have to be 1,040,000 atmos. The multi-stage wire-drawing method described above might be regarded as a thermodynamic ratchet. One possible application of this principle may be indicated. If the pump shown in Fig. 17 be connected to the compression space of the cylinder a of an internal-combustion engine, the temperature of the air in the pipe i may be raised sufficiently high to effect ignition of fuel or of fuel and air in this pipe. If, for example, the air admitted to the pump cylinder by the valve d is wire-drawn to a pressure of one-half an atmosphere and then compressed to a pressure of two atmospheres and discharged through

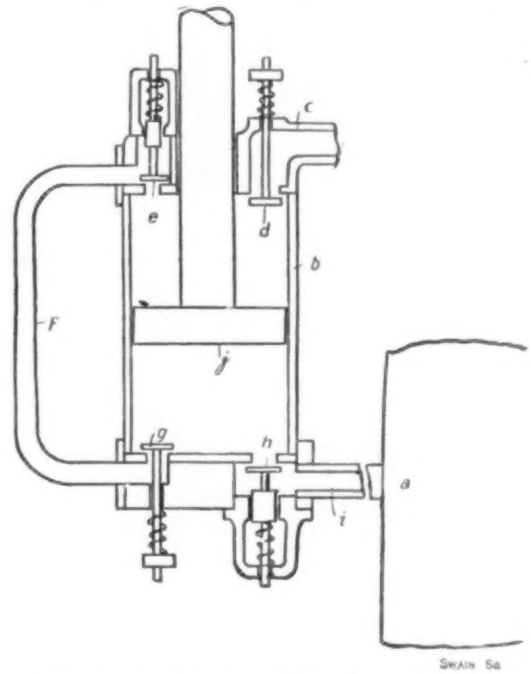


Fig. 17 Pump Arranged to Raise Gas Temperature Dynamically (Watkinson Method)

the valve e into f, where the pressure is one atmosphere, and if the process is repeated on the other side of the piston and the air discharged into the pipe i at a pressure of one atmosphere at the beginning of the compression stroke of the piston of the engine, then the temperature of the air in the pipe i will be the same as if this air had been compressed from one atmosphere to 16 atmos.; and if the compression pressure ratio in the engine cylinder is 10, the air in the pipe or pocket i will at the end of the compression stroke of the engine be at the same temperature as if it had been compressed from one atmosphere to 160 atmos., although its pressure will only be equal to 10 atmos., or that in the engine cylinder with which it is in free communication.

The above discussion would also explain why serious overheating may occur in air compressors having a leaky delivery valve. If, for example, in a single-stage air compressor compressing air to 4 atmos. the delivery valve was held partly open by any means during the charging stroke of the pump, and if it be assumed, as an extreme case, that the backward flow into the cylinder was at such a rate as just to maintain the pressure at one atmosphere during the charging stroke, then after 10 revolutions the air would, under adiabatic conditions, be raised to a temperature of 16,600 deg. cent. abs., and to a very high temperature under actual conditions. The temperature attained owing to such leakage might, in certain cases, be sufficient to cause melting of the valve. In the case of turbo-compressors, backward leakage due to a bent or fractured blade might raise the temperature sufficiently to cause melting of the blades. (Paper before the British Association, Section G, August 1920, abstracted through *The Engineer*, vol. 130, no. 3374, August 27, 1920, p. 198, 2 figs., *tpA*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

National Physical Laboratory of Great Britain

THE Report of the National Physical Laboratory for the year 1919 has been issued. The report includes the report of the executive committee, a statement of the work proposed for the next year, a list of the papers published by the Laboratory or communications by members of the staff to scientific societies or journals, the report of the director, report of special work done in gage testing and other researches during the war. The heads of the various departments give accounts of the recent work in the laboratory. The subjects covered are as follows:

Physics Department:
- I—Heat:
  - *a* High-Temperature and General Work
  - *b* Thermometer Testing
  - *c* Oil-Apparatus Testing
- II—Optics
- III—Radium and X-Ray Work
- IV—Tide Prediction
- V—Library

Electricity Department
Metrology Department
Engineering Department
Aerodynamics Department
Metallurgy Department
The William Froude National Tank

Copies of the Report at 5s may be obtained from the Imperial House, Kingsway, W.C. 2, London.

Petroleum Research

The Petroleum Section of the American Institute of Mining and Metallurgical Engineers held meetings in St. Louis on September 21 and 22. An invitation was extended to the Petroleum Division of the American Society for Testing Materials and the American Association of Petroleum Geologists. The subjects of the papers dealing with research matters were as follows: Urgency for Deeper Drilling on the Gulf Coast, A. F. Lucas; Oil-Field Brines, Chester W. Washburne; Efficiency of the Use of Oil as Fuel, W. N. Best; Determination of Pore Space of Oil and Gas Sands, A. F. Melcher; Outline for Analysis of Oil-Field Water Problems, A. W. Ambrose; The Nature of Coal, J. E. Hackford; Extended Life of Wells Due to Rise in the Price of Oil, W. W. Cutler, Jr.; Oil Shales and Petroleum Prospects in Brazil, H. E. Williams.

Research Associations in Great Britain

In addition to those listed in the March and August issues of MECHANICAL ENGINEERING (pp. 181 and 470), the following Research Associations have received licenses from the Board of Trade under Section 20 of the Companies' Act of 1908:

The British Refractories Research Association, 14 Great George St., S. W. 1; Secretary, R. C. Rann.
The Scottish Shale Oil Scientific and Industrial Research Association, 135 Buchanan St., Glasgow; Secretary, W. Fraser, C.B.E.

The following Research Associations have been approved, but not licensed, in addition to those mentioned previously:

The British Electrical and Allied Industrial Association
The British Silk Association
The British Motorcycle and Cycle Car Research Association
The British Cutlery Association.

The following Associations are preparing Memoranda and Articles of Association in addition to those previously listed:

Jute Spinners and Manufacturers
Gray and Malleable Cast-Iron Founders.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulæ or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Air A2-20 Blasting Granite with Compressed Air. Report on investigation Serial No. 2154 by Oliver Bowles deals with the use of compressed air in the final blasting of granite. In granite quarries where no joints or "sheeting planes" occur, two holes 3 in. in diameter are drilled close together to a depth of about eight feet. A small charge of about a spoonful of black blasting powder is placed in each hole, tamped with clay and fired. This starts a small fracture leading out horizontally from the two holes and by successively larger charges the fracture is enlarged in area until compressed air at 100 lb. can be put in the holes through pipes which have connections made airtight by means of sulphur. This air supplied over an enormous surface exerts an upward pressure and continues the enlargement of the fracture. Address Bureau of Mines, Washington, D. C., F. G. Cottrell, Director.

Apparatus and Instruments A12-20 Method for Measuring Interior Diameter of Ring Gages. A method employing two steel balls, the sum of the diameter of which is slightly larger than the nominal inside diameter of a ring to be measured, has been devised by the Bureau of Standards. The ring is laid on a surface plate and the larger ball placed in the ring and the smaller ball then rests against the inside of the ring, and on the larger ball. The difference in vertical position between the upper surfaces of the two balls is determined by a micrometer. This distance is easily converted into the vertical distance between the centers of the two balls. From this the horizontal distance between the two centers is determined from the right-angled triangle formed by the vertical distance, horizontal distance and distance between centers of the balls. From the above the diameter of the ring is determined. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Apparatus and Instruments A13-20 Quantitative Measurement of Consistency. The Bureau of Standards has developed a method for the quantitative measurement of consistency. This consists in forcing the material under investigation through a capillary tube by means of air pressure. Runs are made at various constant air pressures. Values which are deduced from the readings determine consistency. This does not determine the plasticity, and the Bureau is at work on a plastometer. Scientific Paper No. 276 and Technologic Paper 169, as well as papers in the Proceedings of the A. S. T. M. for 1919-1920, show the application of this apparatus. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Apparatus and Instruments A14-20 Etched Balls for Brinell Tests. When specimens are tested in polished state the impressions from etched balls are very distinct, while those from unetched balls are almost invisible from certain angles. The steel ball is etched for about one minute before the test in a 2 per cent alcoholic nitric acid solution. If the specimens are not polished, preliminary etching of balls does not seem to be of much advantage. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Cement and Other Building Materials A11-20 Penetration of Water. The Bureau of Standards has devised a new apparatus to determine the rate of penetration of water through building materials. No special form of test piece is necessary if one face of the specimen is fairly smooth. A complete test of materials has not been made but from the preliminary investigation the table below has been prepared:

Test Specimen	Absorption in 24 Hours, Per cent	Thickness, In.	Water Pressure, Lb.	Time Required for Penetration through Wall
Limestone 50	5.80	$1\frac{5}{8}$	60	$10\frac{1}{2}$ min.
Limestone 7E	3.10	$1\frac{5}{16}$	60	11 min.
Limestone 8907	4.40	$1\frac{5}{8}$	60	19 min.
Limestone 9c	4.60	$1\frac{5}{8}$	60	$2\frac{2}{3}$ min.
Limestone No. 5G	3.48	$1\frac{1}{4}$		$1\frac{1}{2}$ min.
Sandstone	5.56	$2\frac{1}{2}$	60	10 sec.
1 : 6 Portland-cement mortar	7.8	2	60	$3\frac{1}{2}$ hr.
1 : $1\frac{1}{2}$: 2 concrete	5.8	2	60	(*a*)

(*a*) Did not fail in 24 hr.; when broken through water had penetrated but $\frac{1}{2}$ in.

Fuels, Gas, Tar and Coke A11-20 Gasoline from Natural Gas. Factors in Determining the Gasoline Content in Natural Gas by the Absorption Method is the title of a Report Serial No. 2157 to the Bureau

of Mines by D. B. Dow. This report deals with certain factors which should be considered in making absorption tests to determine the gasoline content of natural gas using "mineral seal oil" as the absorbent. The method is described in Technical Paper 232, Bureau of Mines 1919, by Dykema and Neal. The factors to be considered are the saturation in the absorbent oil which should be as high as possible in the first compartment and low in the third and fourth compartment, the loss in distillation, the rate of distillation, the temperature of the condenser and the stopping of the distillation by means of the mineral seal ring rather than by temperature readings. The rise in temperature to 350 deg. fahr. should take between 12 and 30 min. The condenser should be held at 60 deg. fahr. Bureau of Mines, Washington, D. C. Address M. G. Cottrell, Director.

Fuels, Gas, Tar and Coke A12-20 The Coal Fire. The Department Scientific and Industrial Research through its Fuel Research Board has made a special Report No. 3 on the Coal Fire. This includes the work of Dr. Margaret Fishenden on Domestic Heating, the investigation of the efficiency of open fires and on air pollution from domestic heating. Copies at 4/3 may be obtained from the Imperial House, Kingsway, London, W. C. 2.

Fuels, Gas, Tar and Coke A13-20 Colorado Oil Shale. Martin J. Gavin, Bureau of Mines and Leslie H. Sharp, State of Colorado, have made report No. 2152 to the Bureau of Mines on some physical and chemical data of Colorado oil shale. The experiments were made on samples which represented an average of the massive type of oil shale encountered in Colorado. The results show a yield of 42.7 gal. of oil of 0.905 specific gravity from 2000 lb. of shale. The specific gravity 0.905 or 24.7 deg. B was determined at 15.56 deg. cent. or 60 deg. fahr. The weight of the shale per cu. ft. is given below:

Size	Run of mine	—1 in.	—1/2 in.	—1/4 in.
Weight, lb. per cu. ft.	53.775	54.775	56.015	58.200

The apparent specific gravity varied from 1.92 to 2.06. The specific heat from 20 to 90 deg. cent. varied from 0.223 for spent shale to 0.265 for raw shale. The heat of combustion of raw shale was 2460 calories per gram or 4428 B.t.u. per lb. In making this determination it was found very difficult to get complete combustion, even when using oxygen at 500 lb. pressure. The ash residue in most cases contains considerable combustible matter. The thermal conductivity for ranges of 25 to 75 deg. cent. was 0.0032 in absolute units, for which the conductivity of copper is about 0.91. The proximate analysis shows moisture 0.60 per cent, loss on ignition 40.00 per cent, and ash or residue 59.40 per cent. The analysis of the ash gives about 45 per cent silica, 26 per cent iron and alumina, 18 per cent lime, 5.3 per cent magnesium. The heat of combustion of crude shale oil is 10,215 calories per gram or 18,387 B.t.u. per lb. Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

Glass and Ceramics A2-20 Telescope Objectives. A paper has been prepared by the Ordnance Department which deals with the possible sets of simultaneous values of spherical and chromatic aberration which may be obtained from a two-piece cemented telescope objective of barium crown glass and flint glass. Sets of contours are presented which show in a complete form the manner in which the different aberrations change as the radii are altered. See *Journal of the American Optical Society*. Also S. Tour, Metallurgical Section, Ordnance Dept., Washington, D. C.

Industrial Management A1-20 Code for Head and Eye Protection. The National Safety Code for the protection of head and eyes of industrial workers has just been sent to the press. For two years the rules have been published in mimeographed copies for criticism and correction. The Code specifies appropriate protectors against mechanical hazards such as flying particles, dust, chemical fumes and excessive light. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Iron and Steel A2-20 Boiler Plate at Elevated Temperatures. The tensile properties of boiler plate at temperatures up to and including 563 deg. fahr. are not affected by the rate of loading from very slow loading up to 1.6 in. per min. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Mining, General A4-20 Stench Warning in Metal Mines. A. C. Fieldner and S. H. Katz have made a report on this subject in Serial 2153 to the Bureau of Mines. In order to send warnings, messengers, electric lights, telephones, the interruption of the flow of compressed air or the introduction of water into the compressed-air lines have been used. Experiments have just been made on the introduction of a material which would cause a strong odor or stench that could not be mistaken. The liquids suggested have been ethyl mercaptan (C_2H_5SH) and amyl acetate. Ethyl mercaptan boils at 98 deg. fahr. and freezes at 228 deg. below zero. It has a disagreeable and characteristic skunk-like odor which will not be mistaken for odors commonly found in mines. It can be obtained from certain chemical manufacturers at $2.25 per lb. Amyl acetate may be obtained from any chemical-supply house or from dealers in paints and lacquers. This has a banana-like odor which is not objectionable but distinctive. Tests have been made in a large number of mines proving the effectiveness of ethyl mercaptan. The amyl acetate tests were not so effective in a short time. 1 3/4 pints of ethyl mercaptan or 3 1/2 pints of amyl acetate are required for each 100,000 cu. ft. of free air entering the mine per minute. The injector is constructed of a stout glass cylinder or airtight metal cylinder capable of withstanding the pressure in the line. It is connected above and below the liquid to the air line with short 1/2-in. pipes. Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

Paints, Varnishes and Resins A1-20 Talc in Fire-Resistant Paint. A fire-resistant paint has been prepared by the Paint Manufacturers' Association started through Henry A. Gardner at the Institute of Industrial Research, Washington, D. C., and Dr. Herman Von Schrenk, of St. Louis. The formula for the paint is as follows: 10.6 lb. basic sulphate white lead, 11 lb. zinc oxide, 33 lb. asbestine (magnesium silicate or talc), 0.5 lb. borax, 0.9 lb. dry lampblack, 24 lb. linseed oil, 2 lb. liquid drier and 10 lb. mineral spirits. It is noted that 33 per cent of the paint is talc. Although called asbestine, this is not a form of asbestos. The material is being tested at present by the Underwriters Laboratory. See Report of the Bureau of Mines, Serial No. 2150. Address Bureau of Mines, Washington, D. C., F. G. Cottrell, Director.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Chemistry, Inorganic, B2-20 Ferric Oxide with Small Percentage of Fused Salts. An investigation is being made of the physical and chemical properties of ferric oxide fused with small quantities of various salts. Waltham Watch Co., F. P. Flagg, Chief Chemist, Waltham, Mass.

Glass and Ceramics B3-20 Enamel for Watch Dials. The Waltham Watch Co. is investigating a satisfactory method of determining the properties of the enamel used on watch dials. Difficulties have been encountered in finding satisfactory methods for determining constituents. Physical properties are being studied. These include the coefficient of expansion, viscosity, melting point, opacity and color. Address Waltham Watch Company, F. P. Flagg, Chief Chemist, Waltham, Mass.

Lubricants B1-20 Lubrication at High Temperatures. Tests of viscosities at high temperatures of asphalt and paraffin base oils at 300 deg. fahr. and lower. Address Lockhart Laboratories, L. B. Lockhart, Atlanta, Ga.

Metallurgy and Metallography B12-20 Furnace Linings and Brass Alloys. The effect of different brass-foundry alloys on different refractory materials used for furnace linings in crucible furnaces, open-flame oil furnaces and electrical furnaces. The Lumen Bearing Company, Address C. H. Bierbaum, Buffalo, N. Y.

Metallurgy and Metallography B13-20 Bearing Alloys. A study of the methods of eliminating impurities incident to improper foundry methods for bearing alloys. Address Lumen Bearing Company, C. H. Bierbaum, Buffalo, N. Y.

Metallurgy and Metallography B14-20 Bearing Alloys. The possibility of using new alloys for bearing purposes and limitations of different alloys now in use. Lumen Bearing Company, Address C. H. Bierbaum, Buffalo, N. Y.

Textile Manufacture and Clothing B3-20 Work of the United States Testing Company. The work in progress at the United States Testing Company is devoted to various phases of textile work.

1 Standardization of Fading Tests. Design and construction of special holder for several samples exposed to artificial light. Comparison of results at Rutgers College, University of Nevada, and in New York City.
2 Mechanical tests as a means of classifying raw silks.
3 The effects on the color in finished knit goods of different ways of doubling and twisting in hosiery tram.
4 Some apparent anomalies in the colorimetric estimation of dyestuffs.
5 Lousiness.
6 A comparison of artificial silks among each other and natural silks.
7 Standardization of chemical methods of determining the per cent content of silk, wool and cotton in fabrics.
8 Weighting and durability of silk fabrics.
9 Relation of laundering processes to fastness of colors.
10 Identification of dyestuffs and intermediaries.
11 Soaps and oils for textile work.
12 Photomicrography of fabrics.
13 Determination of the soap and oil content of thrown silk by extraction method.
14 Chemical and physical characteristics of the sericin and fibroin in so-called hard and soft silks.

Address R. E. Douty, General Manager, U. S. Testing Company, 340 Hudson St., New York.

C—Research Problems

The purpose of this section of Engineering Research is to bring together persons who desire coöperation in research work or to bring together those who have problems and no equipment with those who are equipped to carry on research. It is hoped that those desiring coöperation or aid will state problems for publication in this section.

Machine Design C2-20 Ball Bearings at High Speeds. The performance of ball bearings at from 7,000 to 25,000 r.p.m. is being investigated theoretically by Panfilo Trombetta. Investigation of a theoretical and experimental nature is desired. Address Panfilo Trombetta, General Electric Company, Schenectady, N. Y.

Metallurgy and Metallography C2-20 Cartridge Brass. Relation between hardness, tensile strength and amount of cold work on cartridge brass containing 68 to 71 per cent copper, 32 to 29 per cent zinc, and not less than 0.07 per cent lead and not less than 0.05 per cent iron. In the annealed condition the relation between hardness and grain size is known. The relation between the amount of cold work, hardness and tensile strength for metals of different grain size is desired. Address S. Tour, Metallurgical Section, Office of the Chief of Ordnance, Washington, D. C.

Metallurgy and Metallography C3-20 Overstrain in Steel. The effects of overstrain on steel and the influence of time and temperature on these effects. The statement that elastic limit of steel may be increased by cold work or by the application of excessive stresses is often made. It is desired to know the physical characteristics of steel subjected to cold work or to excessive stresses above the elastic limit and the effect which time and temperatures less than 600 deg. cent. have upon these characteristics. Address S. Tour, Metallurgical Section, Office of the Chief of Ordnance, Washington, D. C.

D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work may be done.

Simonds Steel Mills D1-20 Simonds Manufacturing Company has just completed an addition to its research laboratory at its steel mills in Lockport, N. Y. The building is 40 by 50 ft. New equipment consisting of a special-type electric melting furnace of 300 to 500 lb. capacity and electric heating furnaces with other equipment for extending facilities for research and development work has been added. New formulæ and methods for making special steels are being worked out under the direction of an expert metallurgical staff.

Doehler Die-Casting Company D1-20 Laboratories equipped for making chemical and physical tests of materials, particularly those used in non-ferrous alloys and especially alloys used in die casting. Doehler Die-Casting Company, Address Charles Pack, Chief Chemist, Court, Ninth and Huntington Sts., Brooklyn, N. Y.

E—Research Personnel

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. or to others recommended by members of the A.S.M.E. These bibliographies are on file in the offices of the Society.

CORRESPONDENCE

Contributions to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this Journal, brief articles of current interest to mechanical engineers, or suggestions from members of The American Society of Mechanical Engineers as to a better conduct of A.S.M.E. affairs.

Can Engineering Students be Given Broad Conception of Production and Management?

To the Editor:

Mr. Benedict describes in his paper in the September number what he modestly offers as a partial contribution toward the improvement of engineering schooling. His work exemplifies current systems of shop operation and management. This covers a considerable part of the field of industrial engineering, but not the whole field. Engineers, and particularly mechanical engineers, are too apt to think of machine-shop operation as typical, if not inclusive, of production generally. A result is that in those industries which are quite dissimilar from the shop, engineers class themselves as mechanical men rather than as production men.

If applications of engineering are to be taught in the schools, other industries as well as the shop should have attention. A very few may be mentioned: steel manufacture; the refining of petroleum products; sugar processing; the manufacture of pulp and paper. Shop methods cannot be applied, unmodified, in the production departments of these industries.

Few schools if any can have model paper mills or sugar refineries. They can teach, do teach and should continue to teach, the scientific principles underlying these and all industries. They must now also attempt to develop and teach operation and management principles. There must consequently be some study of operation. This cannot in general be carried on in the experimental way which Mr. Benedict develops for the shop. It must be done by industrial research or survey conducted by means of seminar or thesis assignments, including visits to manufacturing plants. These visits should be of a month or two in duration, not of an hour or two. They will make graduates more immediately useful in the special industries examined; but this is not the main point, or the chief function of the school, which should be concerned with the producing power of its graduate over his whole economic life. The real advantage of the study of typical industries is in its broadening and stimulating effect, and in its confirmation or illustration of fundamental principles.

To carry out such a program requires a rather unusual amount of coöperation from the manufacturers, and the manufacturers must not expect too much immediate or direct benefit. Education is about the longest-range operation we have today.

The new professional course in industrial engineering, which has just been announced by Columbia University, has been prepared with some of these points in mind. Studies are grouped under General Engineering, Business, Machinery, and Industrial. In the last group provision is made for four months, work in a factory, half the time as a student-worker and the balance in directed study and analysis. The major courses in this group are those dealing with manufacturing processes and it is interesting to note that the non-metallic industries are assigned fully half the total time. Processes and mechanical operations are analyzed and the characteristics of machines examined. In the third year of this graduate course each student selects and studies, under guidance, some particular industry. This need not be (although it often will be) a metal-working industry. The study will include a survey of commercial, financial and technical factors, with contemplation of ways and means for improvement. As a test of accomplishment, a final course aims to develop methods of analysis by which the machinery and equipment may be selected for manufacturing an assigned commodity according to an assumed schedule. A part of the job is the preparation of a financial budget for the operation.

The obvious reflection in connection with a program as ambitious as this is that it requires teaching of unusual type and scope. But with the right sort of handling the value of work of this kind should be very great.

132 Naussau St.
New York, N. Y.

William D. Ennis.

The New Ford Plant at River Rouge, Mich.

Notes of Interest Regarding the Features of This Unique Plant, Gathered Through the Visit of the Cleveland Engineers

MENTION was made in the last number of the recent excursion of the Cleveland engineers to Detroit, and of the visit to the new Ford plant at River Rouge. In *Cleveland Engineering* for September 7, the journal of the Cleveland Engineering Society, is an account of the trip, from which the following notes are taken:

About the Ford Plant

Heretofore, iron ore—the rock itself as it is taken from the mine—has never been listed as an automotive part. Even the most completely equipped, self-contained automotive factory, a plant fabricating steel and manufacturing a majority of the units going into its product, has never gone back farther than iron pigs and raw steel.

At River Rouge, one of Detroit's western suburbs, this dream of Henry Ford's is approaching realization. The Clevelanders found River Rouge the scene of an industrial development program of such proportions that its scope is almost incomprehensible.

Points of interest were the waterway, storage yards, by-product plant, blast furnaces, a large body plant which formerly was the Eagle boat plant, power house and foundry, the latter three in course of construction.

The waterway consists of a turning basin large enough for the longest lake vessel, and a slip half a mile long, 250 ft. wide and 25 ft. deep. The Government recently has begun contract work on the widening and deepening of the River Rouge for a distance of two and a half miles from the plant to the Detroit River, which will put the plant on the 22-ft. waterway of the lakes. The visitors had an opportunity to see the hydraulic dredges at work.

The storage yards for coal, stone and ore, just completed, were inspected. The boat-unloading equipment was not operating, pending completion of the Government channel. Meanwhile the company gets its ore by rail.

The by-product plant was in full operation, turning out coke, illuminating gas, light oil, tar and ammonium sulphate.

The plant in general occupies about 23 acres. When Mr. Ford's entire project is realized it will take in a site of nearly a thousand acres. The 120 coke ovens produce 1700 tons of coke, 18,000,000 cu. ft. of gas, 10,000,000 of which is being sold to the city of Detroit, 4000 gal. of benzol, 16,000 gal. of tar and 27 tons of ammonium sulphate, sold as a fertilizer.

Each of the four blast furnaces will have a capacity of 500 tons of iron daily. Every casting and steel part used in the Ford automobile, truck and Fordson tractor will be manufactured at River Rouge when the plant enters into full production.

The power house will consume 1000 tons of coal daily. When complete it will contain turbo-generators of 65,000 kw. capacity and five turbo-blowers of 40,000 ft. capacity a minute. Five 2000-ft.-a-minute air compressors will supply air to the plant for manufacturing purposes. Eight 2640-hp. boilers will be fired by blast-furnace gas and pulverized coal.

The plant is unique in three respects. It will be the first complete consolidated blast furnace, foundry and steel mill in the world. It will be the first large power plant in this country to utilize pulverized coal. It will be the first to make castings from metal coming directly and uncooled from the blast furnaces. This is a feat which engineers have said could not be done.

In engineering circles, the announcement that the Ford company planned to pour hot metal directly from the furnaces to molds, eliminating the remelting of pig iron in the foundry cupolas, has been received with unusual interest.

It was this feature that the Cleveland visitors were particularly anxious to see. However, pending completion of the foundry, the metal is being made into pig and the engineers had to be satisfied with an explanation of the process. In working this process out the cupolas have not been eliminated entirely, but the metal from the furnaces and the metal from the cupolas will be mixed in definite proportions.

At the time of the excursion pamphlets were distributed by the George T. Ladd Co., Pittsburgh, Pa., on the boilers which they are building for this plant, probably the largest boilers ever constructed, with brief reference, also, to the superheaters and method of firing. The pamphlet states:

Boilers of the Power Plant

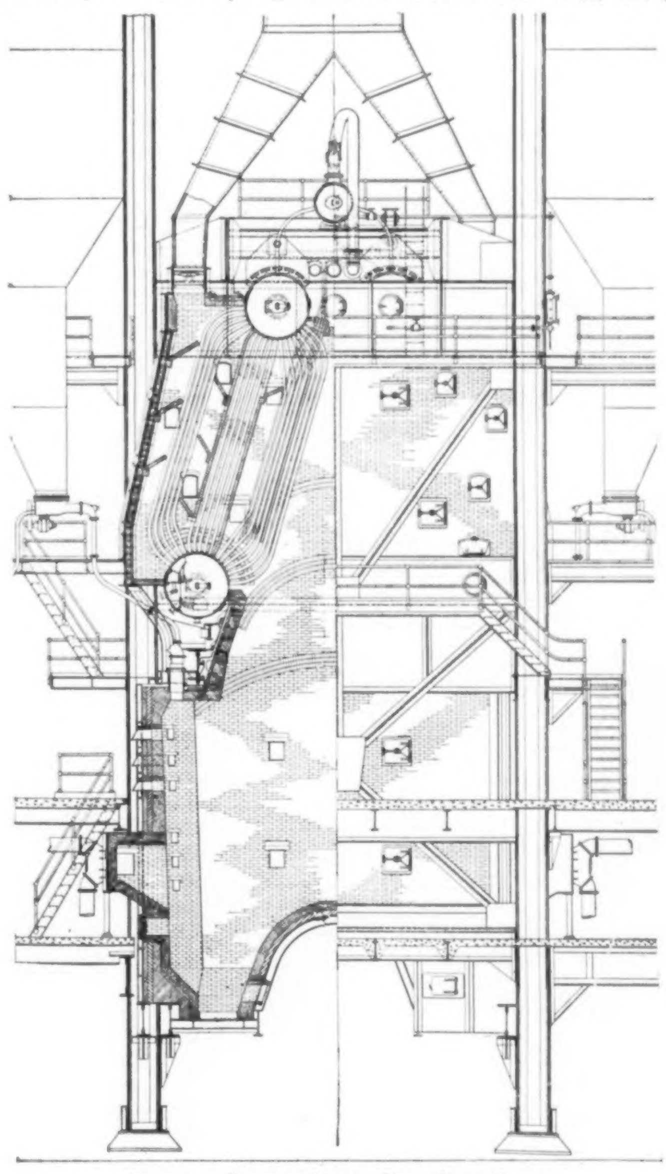
These boilers each contain 26,470 sq. ft. of heating surface, which is exclusive of superheater heating surface, or surface of future economizer. Inasmuch as this heating surface is substantially all in the tubes, it required for each boiler nearly six miles of $3^1/_4$-in. tubing. Steam will be generated at 240 lb. per sq. in. and superheated 200 deg. fahr.

The main steam and water drums are 5 ft. inside diameter by 25 ft. $10^3/_4$ in. long, with $^{15}/_{16}$-in. thick shell plates. The steam is led from the two main top drums to a 36-in. steam drum equipped with two 10-in. nozzles, which connect with the two saturated-steam headers of the superheater.

The furnace, while irregularly shaped, is approximately 23 ft. by 24 ft. inside by 55 ft. high above the ashpits. The combustion space allowed by this furnace, exclusive of ashpits, is about 5 cu. ft. per normal rated horsepower. The total height of the boiler from the ashpit floor to the top of the superheater piping is 82 ft. $9^7/_8$ in.

The settings of the boilers presented many difficulties owing to the extreme size of the furnaces. The lower main walls are $33^3/_4$ in. thick at the haunches with a 9-in. vertical invert at the center. All the high-temperature zones in the furnace are lined with $13^1/_2$ in. of firebrick. A sectional view and side elevation of one of the boilers and its setting are shown in the accompanying illustration.

Economizers are not to be installed at the start, but provision is made in the structure for their future addition. The superheater arrangement, however, permits a full 3-pass gas travel for each side of the boiler, which,



Sectional View of Boiler Unit, Ford Plant

coupled with the fact that the passes can be baffled as closely as is consistent with the ratings desired, seems to assure reasonably low stack temperatures. Mounted over each boiler and supported by the building framing will be a steel stack 11 ft. inside diameter, with the top reaching 327 ft. above the ash-floor level.

Superheaters

Each superheater consists of three headers, two 10 in. in diameter and one 12 in., all approximately 23 ft. long, together with the connecting elements.

The headers are located below the boiler steam drum, with the larger in the center and the two smaller on each side. Steam is taken from two points on the boiler collecting drum and led to the ends of the 10-in. saturated-

(*Continued on page 654*)

MECHANICAL ENGINEERING

The Monthly Journal Published by The American Society of Mechanical Engineers

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Yearly subscription, $4.00, single copies 40 cents. Postage to Canada, 50 cents additional; to foreign countries $1.00 additional.

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

Mechanical Engineering Changes Printers

For the past ten years, MECHANICAL ENGINEERING has been printed at the plant of the Williams Printing Company, New York, one of the largest, best-equipped and best-organized printing establishments in the country. The service which this company has rendered has been of the highest order and the careful attention which its employees have given to the execution of the work upon MECHANICAL ENGINEERING has been all that could be desired, and deserves the highest praise. The rapidly rising cost of production in the printing industry, however, has made it seem advisable to the Publication and Papers Committee of The American Society of Mechanical Engineers to have the printing done in a smaller city where the overhead charges and cost of living, and consequently cost of production, are lower than in New York. Accordingly, this journal is now to be printed by the Eschenbach Printing Company, Easton, Pa., which, under the postal laws, becomes the publication office. The editorial and business offices will remain at the headquarters of the Society, 29 West 39th Street, New York, and all communications should be sent to the New York address.

It probably is not realized by the average person that the increases in costs in the publishing business have been greater since the beginning of the war than in almost any other line of industry. We are accustomed to think of the prices of commodities as having advanced about 100 per cent during this period; but if the cost of publishing had advanced *only* 100 per cent, those who issue periodicals would now be supremely happy and would have no cause for concern. The following items give the percentages of increase which have occurred since 1914 in the production of journals like MECHANICAL ENGINEERING and indicate how great has become the expense of issuing a periodical:

PER CENT INCREASE IN PRINTING COSTS SINCE 1914

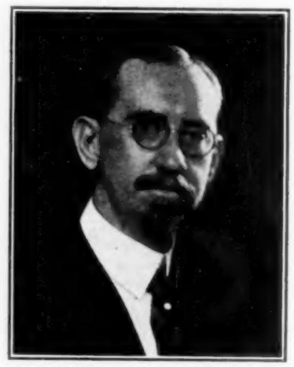
Machine Composition	105
Hand Composition	218
Presswork	170
Binding	118
Paper	300
Engravings (inch rate)	110
Engravings (minimum sizes)	275

The greatest advances have occurred during the past two years, and to a large extent since the printers' strike in New York City last fall. Nevertheless, the Society has not only maintained MECHANICAL ENGINEERING during this trying period on the same basis and with the same complete presentation of its matter as in previous years, but in addition has made notable improvements, one of which is the inclusion of The Engineering Index.

As for the new printers, the Eschenbach Printing Company has for many years handled the publications of the American Chemical Society and is well equipped for scientific work. Its facilities are to be enlarged to accommodate MECHANICAL ENGINEERING, and while it has not been possible to secure the complete installation of machinery and materials in time for the present number, new presses and composing-room equipment will shortly be in place. For several years past this company has printed Condensed Catalogues, the superior appearance of which is evidence of the workmanlike manner in which its printing has been handled.

In one respect, at least, it is hoped to render better service in the new location than heretofore, namely, in the distribution of MECHANICAL ENGINEERING through the mails. There have been frequent and annoying delays because of the congestion caused by the tremendous amount of printed matter which has to be handled by the New York Post Office, a condition which does not exist to a like extent in the smaller cities.

The Superpower Survey



WILLIAM S. MURRAY

IN 1905 Mr. W. S. Murray, chairman of the Superpower Survey, was called to the New York, New Haven and Hartford Railroad Company to supervise the electrification of its lines adjacent to New York. This brought forcibly to his attention the economic advantages resulting from the consolidation of power units for the electric distribution of power for industrial and railroad purposes. It is therefore greatly to his satisfaction that Congress has authorized an investigation of the possibilities of the superpower system for the eastern section of the country, which is creating so much interest among engineers and others connected with our industrial plants and transportation systems.

The proposed plan has for its central idea the construction of an electrical regional power system applicable to the industries and railroads existing within the territory between Boston and Washington and inland from the coast 150 miles. By the installation of high-powered, high-economy tidewater steam plants, hydroelectric stations, and steam stations located at the mouth of mines, all interconnected with a transmission system, and using also the large central stations now built and located at the larger cities, such as in Boston, Providence, New York Philadelphia, and Baltimore, there can be integrated one great regional power system from which power can be delivered to the industries and railroads.

The area above-mentioned is the most congested industrial and railroad district in the United States. Here are located hundreds of steam-electric power plants, mostly of small capacity, using on a conservative estimate an average of 40 lb. of steam per kw-hr., as against the probable rate of 15 lb. when supplied from the superpower system. In Mr. Murray's opinion the machine capacity of this district is 17,000,000 hp., of which 10,000,000 is industrial and 7,000,000 railroad. The load factor is not over 15 per cent instead of 50 per cent or more which would result if power were concentrated on a single bus system and distributed therefrom to the industries and railroads.

By such concentration of power there would also result an enormous saving in maintenance through the substitution of electric for steam drive in the factories and on the railroads, and also by the reduction of train-miles on the railroads by virtue of the ability of the electric locomotive to consolidate a greater tonnage in single trains. Automatically, also, labor and maintenance costs at the mines would be greatly reduced and cargo space on

the rails now required for useless coal haulage released for other commodities so urgently needed at the present time. Preliminary estimates indicate that the total annual saving from these various results would aggregate $300,000,000.

Facts such as these were brought out at meetings of the American Institute of Electrical Engineers and of other societies, and finally led the Engineering Council, the central body of the national engineering societies of America, to pass a resolution at a meeting held a year ago this month, advocating an appropriation by Congress for a survey of the superpower project. In April, 1920, a committee, of which Mr. Murray was chairman, was appointed by the Council to present the matter before the Appropriations Committee of the House of Representatives. The hearing was held March 18, and testimony was given by Prof. L. P. Breckenridge, Mem.Am.Soc.M.E.; Prof. D. C. Jackson, Mem.Am.Soc.M.E. and Past-President of the A.I.E.E., and Mr. Murray. The case was reported favorably to the House and ably presented there by Chairman Good of the Appropriations Committee; and $125,000 was appropriated for the power survey.

The work is now being prosecuted by an organization known as the Superpower Survey, under the jurisdiction of the U. S. Geological Survey, with headquarters at 709 Sixth Avenue, New York City. Mr. Murray has divided his engineering staff into three departments of investigation: (1) Power and Transmission; (2) Railways; and (3) Industries, with a division chief at the head of each and an engineer-secretary assigned to the duty of collaborating with these division chiefs in collecting and collating data.

The services of the chief hydraulic engineer of the Geological Survey and of the chief mechanical engineer of the Bureau of Mines are being contributed in part to the engineering staff of the Superpower Survey. Further assistance is being rendered by an Advisory Board of men representative of power producers and power consumers, and of the people as a whole representing a national power policy. Mr. Murray has selected and the Secretary of the Interior has appointed to membership on this Board, gentlemen who would be representative of New England railroads, New York railroads, engineering, technical publicity, the National Electric Light Association, the American Electric Railway Association, and the National Industrial Conference Board. Prof. L. P. Breckenridge, of Yale University, is chairman of this Advisory Board.

The superpower project, in Mr. Murray's opinion, which is in accord with others, marks the beginning of a national power policy and he believes its advantages as developed for the eastern district will be applicable to other districts in other parts of the country, and will constitute one of the most important movements ever developed for the conservation of our fuel and for the economical production of needed products. It will serve to speed up, increase and maintain production in this country at a high point of efficiency, and give to the public a service such as they have a right to demand. [Prepared from notes supplied to Mechanical Engineering by Mr. Murray.—Editor.]

Engineers in Public Service

It is gratifying to know that others besides engineers are coming to recognize that the type of mind and the training of the engineer tend to qualify him for responsible executive positions in the service of the public. We all know that, as city managers, members of public-service commissions, etc., they have been for some time rendering valuable and appreciated service.

It is safe to say that Herbert Hoover is perhaps the most widely known and most generally admired public man, the world over, now living.

A member of The American Society of Mechanical Engineers, Mr. Norman J. Gould, is a member of Congress, and James Hartness, Past-President, Am.Soc.M.E., has recently been nominated by the Republicans for Governor of Vermont—a nomination which is generally conceded to be equivalent to election.

Governor Cox has said that when elected he will try to induce Mr. Hoover to enter his Cabinet; and that Governor Cox believes in engineers for executive work was further shown by an incident related to me in a conversation I had with Mr. H. S. Riddle, Mem. Am.Soc.M.E., of Columbus, Ohio, on June 2, which, it will be noted, was some time before the nominating conventions. Mr. Riddle is President of the Ohio Board of Administration and as such he has general charge of all the institutions of the state except the penitentiary. In the course of a conversation about his work he told me, incidentally, how he came to undertake it.

Shortly after Governor Cox took office for his first term, now nearly six years ago, he asked Mr. Riddle to come to his office. On arrival, Mr. Cox said he had been looking for a man to administer the state institutions—had been informed that he, Mr. Riddle, was the man for that work and he asked him to accept the appointment. Mr. Riddle replied to the effect that he was not looking for a job and besides, said he: "Governor, I don't know as you and I would get along so very well, for you are a Democrat, while I am a Republican." Thereupon Mr. Riddle was assured that what was wanted was a man who could and would manage the state's institutions as they should be managed. Investigation had shown that Mr. Riddle was such a man and what his politics might be made no difference. Mr. Riddle thereupon recognized it as his duty to accept and he still holds the position, which I am sure he fills in a very able manner.

The incident shows that engineers, without regard to their politics, are being more and more sought by public officials for service in the conduct of public work, even when that work is not strictly of an engineering character; and that, I think, is cause for gratification.

Fred J. Miller.

Saving the Natural Gas

The growing apprehension as to the possible (and probable) early exhaustion of the natural-gas supply has led to several important developments for its conservation and economy in its use.

The main influence in this direction has been the effective work of the National Committee on Natural Gas Conservation, appointed last January by former Secretary Lane, which has worked in coöperation with the U. S. Geological Survey of the Department of the Interior. On June 11 this committee made a final report at a conference of Governors and members of public-utility commissions of the natural-gas-producing states, held at Washington, D. C., in which were incorporated rules and regulations for gas production, transmission and utilization.

The spirit of these recommendations has been admirably expressed in an administrative order issued last August by the Public Utilities Commission of Ohio. This order designates two classes of consumers of natural gas: domestic consumers and industrial consumers, and so classifies these as to indicate in what order service is to be discontinued during an emergency in order to conserve a supply of gas for domestic consumers, and in what order service is to be restored when the emergency is past.

Domestic consumers include the users of gas for heating, lighting and cooking in private homes and apartments, but for lighting and cooking only in hotels, restaurants, etc. Industrial consumers are divided into three classes, comprising (1) plants producing food on a large scale, (2) power plants with gas engines, and (3) those not included in the first two classes. When there is not sufficient gas for all consumers, the surplus is to be furnished to them in the order above named. If, after disconnecting all industrial consumers, there is not a sufficient supply for the domestic consumers, there is to be a limited curtailment of use for heating purposes which, as the supply becomes much more restricted, will make it incumbent for householders to install auxiliary heating equipment.

A further recommendation, emphasized also by the National Committee, is that all distributing companies make a study of the best and most economical methods of using natural gas, and that a campaign of education be carried on among consumers. This thought was further advanced in a proclamation issued by the Governor of Ohio.

In the same spirit was a conference held in September at White Sulphur Springs, West Virginia, attended by the public-service commissions of the gas-producing states and representatives of the leading gas companies and gas associations. Definite recommendations were made to the natural-gas companies for the coming

winter, calling for more efficient domestic gas appliances and classification of domestic and industrial consumers, and a survey of the territory served by the different companies.

Still another phase of the situation is the law recently passed by the State of West Virginia, known as the Steptoe Law, which provides that the natural gas produced in West Virginia may not be used outside of the state until after all the requirements and demands of home consumers had been supplied. This law has been contested by the states of Ohio and Pennsylvania to enjoin West Virginia from enforcing their law, and the case is now pending in the Supreme Court of the United States. At a recent hearing, Mr. S. S. Wyer, Mem.Am.Soc.M.E., natural gas engineer for the U. S. Bureau of Mines, opposed the West Virginia law.

At the conference at White Sulphur Springs, Prof. I. C. Church, state geologist of West Virginia, testified that from 75 to 90 per cent of gas deposits in Ohio are gone, and three-quarters of the known gas territory in West Virginia is already exhausted. The necessity for conserving the remaining available supply for the benefit of domestic consumers makes it apparent that the use of natural gas for industrial purposes must ultimately be discontinued; even at present there are occasions during periods of extreme cold when the gas supply is insufficient for domestic consumers alone, which indicates that gas for house heating will have to be restricted in order to conserve the supply for cooking and hot-water heating.

The Water Power Act

With the passage of the Water Power Bill during the last session of Congress, the way has at last been cleared for the development on a large scale of a hitherto neglected source of power. It is true that in the past there has been some utilization of our water-power resources, but for the most part it has been confined to limited sections of the country. While this condition can be traced in part to the low costs of fuel and transportation which formerly prevailed, the controlling factor, nevertheless, has been the limitations imposed by the Government restrictions growing out of the fear of the usurpation of national resources by private interests.

Heretofore Government permits for the development of water-power sites have been revocable at will, and thus the business world has hesitated to embark upon such ventures. The new water-power bill, however, removes this uncertainty, as licenses will now be granted for a term of fifty years and at the end of such time may be renewed; or the Government, if it sees fit, may take over the development, giving, of course, proper compensation to the owners. Such a provision cannot fail to encourage investors.

By the passage of the bill water power now comes to the fore as a national resource of the greatest importance, and to the end that its readers may be kept in touch with the latest developments in this field, Mechanical Engineering presents elsewhere in this issue a summary of the regulations governing the administration of the newly enacted law.

Ground Broken for Vehicular Tunnel Between New York and New Jersey

On October 12, 1920, at Canal and Washington Streets, New York City, the first ground was broken for the vehicular tunnel to be built between New York City and Jersey City. The ceremony was held under the auspices of the New York State Bridge and Tunnel Commission, George B. Dyer, Chairman, and The New Jersey Interstate Bridge and Tunnel Commission, W. H. Noyes, Chairman.

The first work to be done on the tunnel is the construction of two ventilating shafts at the Manhattan end of the tunnel, located respectively at Canal and Spring Streets, near Washington Street. These shafts, which are 60 ft. and 54 ft. deep, respectively, will form permanent ventilating openings connecting with the tubes. The specifications show few material differentiations from the former practice in New York subway work. The chief change is in waterproofing, cotton fabric and asphalt being specified instead of burlap and coal-tar pitch because it is thought that the hot asphalt in compressed air will give less trouble in the matter of fumes than the coal-tar pitch. C. M. Holland, chief engineer, states that the type of ventilating shaft specified makes it feasible for the subsequent tunnel work to be done either by the shield process or by the trench method.

High-Speed Machinery

Under the Survey of Engineering Progress in the present issue is described a single-stage air compressor, operating at a normal speed of 22,000 r.p.m., which has been shipped by an American concern to South America. In many respects this is a significant installation. The very fact that a device of this character has been adopted for use in South America, where repair facilities are comparatively scarce, and not always adequate, shows the confidence both of its makers and purchasers in the reliability of the apparatus, notwithstanding the fact that it runs at such great speed.

Great speeds of rotation such as now met with in different types of apparatus have been achieved only by satisfying certain previously prescribed conditions as to materials, workmanship and means for balancing, etc. When it is stated that in the blower referred to, one ounce at the tip of the rotor exerts a stress due to centrifugal forces equal to something like $3^1/_2$ tons, it will be realized that not only materials capable of withstanding these immense stresses must be used, but also materials not subject to fatigue within extremely severe limits; and still further, methods of producing parts that will insure a very great range of safety.

Special steels, such as nickel-chrome and nickel-chrome-vanadium, together with great skill and care in the manufacture of ferrous alloys, have solved the problem as to the raw material, while, in the instance mentioned, modern methods of forging enabled the shaft and blades to be produced out of a single piece, which helped materially in the direction of necessary excellence of workmanship.

But before these tremendously high-speed machines could be made commercially practicable, a good deal of research in the field of mechanics of fast-revolving parts had to be done. It is only within the most recent time that engineers have succeeded in obtaining a clear comprehension of the laws governing the critical speeds of shafts, whirling phenomena, and the balancing of rotating parts generally, and have evolved methods for observing and measuring dynamic unbalance and for correcting errors therein. This was a somewhat tedious research, requiring an unusually skilful use of both mechanical and mathematical tools of investigation, and the success of modern high-speed machinery shows how well this work has been accomplished.

It should be clearly understood that the use of machinery running at speeds of 20,000 r.p.m. and upward is not merely an engineering "stunt" but is an answer to a very urgent requirement. In some cases, as, for example, with blowers, it permits a more compact design of machine and achieves in a more efficient manner what could also have been done with slower-running machinery. On the other hand, there are cases where a problem can be solved only by the use of such high-speed machinery, as, for example, in the case of the Alexanderson high-frequency generator for wireless telegraphy. There is another class of electric generators, namely, the commutatorless direct-current generator, where the ability to run at these high speeds appears to be a valuable characteristic. The significance of such machines as the DeLaval blower and the Alexanderson high-frequency generator for wireless telegraphy lies just as much, however, in the fact that it shows to what a state of perfection modern engineering has arrived in the production of materials and parts capable of withstanding truly tremendous stresses, and in the comprehension of the hitherto obscure phenomena of dynamic balancing and critical speeds of fast-rotating parts.

A natural-gas primer has been issued by the State of Ohio for use in its public schools. This pamphlet, which was originally issued by the U. S. Fuel Administration, deals in the simplest manner possible with the production and distribution of natural gas, the need for its conservation, and its economical use in the home.

Federal Power Commission Adopts Regulations

Commission Charged With Administering the New Federal Water Power Act Announces Adoption of Ten Rules Covering Procedure to be Followed in the Securing of Licenses and Permit

THE Federal Power Commission, which is charged with administering the Water Power Act, has adopted a set of comprehensive regulations covering the procedure in connection with the securing of licenses and permits. These regulations, ten in number, are of vital importance to the work of the Commission, as already many applications have been received, and if the present rate is maintained they will total before January 1 at least 4,000,000 horsepower.

The regulations just issued cover such matters as (1) Definition of Terms, (2) Applications—General Requirements, (3) Applications for Preliminary Permits, (4) Applications for Licenses—Major Projects, (5) Applications for Licenses—Minor Projects, (6) Applications for Licenses—Major Projects Already Constructed, (7) Declarations of Intention, (8) Priorities, (9) Permits, and (10) Licenses. Regulations (9) and (10) are of particular importance to those interested, and for that reason are given below in full.

The passage of the Federal Water Power Act concludes twelve years of effort for satisfactory water-power legislation. In accordance with its provisions the Secretary of War, the Secretary of the Interior, and the Secretary of Agriculture became a Commission to administer the Act and at their first meeting the Secretary of War was appointed chairman and O. C. Merrill, who at that time was chief engineer of the Forest Service, was made executive secretary.

The work of the Commission has been divided into engineering, accounting, statistical, regulatory, licensing, legal, and operation. The engineering division is regarded as the most important as it will make general investigations of the electric power industry, power sites, costs and developments. It will also report results of its examinations to Congress preparatory to construction work of the United States; examine and revise plans for development of streams upon which applications for licenses are made; consider construction plans proposed by licensee; and when already existing plants are brought under the Act will fix the necessary stipulations as to maintenance, development, and operation.

(9) Permits:

A—Except as hereinafter provided, preliminary permits may be issued on the application of citizens, associations, corporations, States or municipalities desirous of obtaining licenses for the construction, maintenance or operation of dams, water conduits, reservoirs, power houses, transmission lines, or other project works necessary or convenient for the development and improvement of navigation, and for the development, transmission and utilization of power across, along, from or in any of the navigable waters of the United States, or upon any part of the public lands and reservations of the United States (including the Territories), or for the purpose of utilizing the surplus water or water power from any Government dam.

B—Permits will be issued only for the purpose of enabling applicants to maintain their priorities while securing the data required for an application for license and will be for such periods, not exceeding a total of three years, as in the judgment of the Commission will be necessary for studying the proper location and design of the project; for making examinations, surveys, maps, plans, specifications and estimates; for conducting stream measurements; for sinking test pits or making borings to determine foundations for dams or other structures; for securing a market for the power to be developed; for making financial arrangements; or for any other purpose necessary or desirable in the preparation of application for license.

C—Permits will not be issued for projects already constructed; for transmission lines alone; for projects of a power capacity of less than 100 horse power; for projects which, in the judgment of the Commission, do not come within the scope of its authority under the Act, or should be undertaken by the United States itself, or do not propose adequate schemes of development, or would unreasonably interfere with projects under permit, license or other authority theretofore granted; or for projects for which date sufficient for filing application for license are already available. Permit affecting any reservation will be issued only after a finding by the Commission that the proposed use will not interfere or be inconsistent with the purpose for which such reservation was created or acquired. Permits will not be issued until after the expiration of the publication period prescribed by the Act.

D—In acting upon applications for preliminary permits, and in determining preferences therefore, the Commission may in its discretion upon the request of any applicant or upon its own motion, hold hearing, order testimony to be taken by deposition, summon witnesses, or require the production of documentary evidence.

E—No charges will be made for permits, but permittees will be required as a condition of maintenance of priority, to perform such work and to make such studies and investigations, and such reports thereon, as in the judgment of the Commission may be necessary or desirable to enable both the applicant and the Commission to determine the feasibility, and the character and extent of development, which is proposed or which should be undertaken, which requirements will be expressed in the permit.

F—Upon a satisfactory showing of reasons, therefore, the Commission may authorize permittees to perform such construction work as may be necessary to maintain water rights under State law, or as may be desirable in preparation for the construction of project works; but the granting of such authority shall not be deemed to have created any equities or to have established any rights beyond what would have been created or established had such authority not been given.

H—Each preliminary permit shall set forth the conditions under which priority shall be maintained and a license issued, and shall also set forth the essential terms and conditions of such license.

(10) Licenses:

A—Except as hereinafter provided, licenses may be issued either in accordance with the provisions of preliminary permits or upon direct application therefore by citizens, associations, corporations, States or municipalities, for the purpose of constructing, operating, and maintaining dams, water conduits, reservoirs, power houses, transmission, and utilization of power across, along, from or in any of the navigable waters of the United States, or upon any part of the public lands and reservations of the United States (including the Territories), or for the purpose of utilizing the surplus water or water power from any Government dam.

B—Licenses will be issued for such periods, not exceeding fifty (50) years, as in the judgment of the Commission, will in each individual case, allow for the satisfactory development and operation of the project and protect the public interest, and shall remain in full force and effect for such periods unless surrendered or terminated as provided in these regulations or revoked as provided in the Act.

C—Licenses will not be issued for projects which, in the judgment of the Commission, do not come within the scope of its authority under the Act, or should be undertaken by the United States itself, or do not propose adequate schemes of development, or lack satisfactory showing of financial ability, or would unreasonably interfere with projects under permit, license or other authority theretofore granted, or would be opposed to the public interest. No license affecting the navigable capacity of any navigable waters of the United States will be issued until the plans of the dam or other structures affecting navigation have been approved by the Chief of Engineers and the Secretary of War. Licenses within any reservation will be issued only after a finding by the Commission that the license will not interfere or be inconsistent with the purposes for which such reservation was created or acquired. Licenses will not be issued until after the expiration of the publication period prescribed by the Act.

D—Licenses may be altered only upon mutual agreement between the licenses and the Commission. Any such alteration shall be made a part of the license and a substitute for the provision altered, but no such alteration shall operate to alter or amend or in any way whatsoever be a waiver of any other part, condition, or provision of the license.

E—Licenses may be surrendered only upon mutual agreement between the licensee and the Commission, and upon the fulfilment by the licensee of all obligations under the license, with respect to payment or otherwise, existing at the time of such agreement, and, if the project works authorized under the license are constructed in whole or in part, upon such conditions with respect to the disposition of such works as may be determined by the Commission.

F—Licenses may be terminated by written order of the Commission after such reasonable notice, not exceeding ninety (90) days, as the Commission may grant, if there is failure to commence actual construction of the project works within the time prescribed in the license, or as extended by the Commission. Under similar conditions and upon like notice the authority granted under a license may be terminated with respect to any project works or separable part thereof covered by the license, if there is failure to begin construction of such project works or part thereof within the time prescribed in the license or as extended by the Commission; but no part of the project works shall be deemed separable for the purposes of this regulation unless so specified in the license.

G—Licenses may be revoked only through proceedings in equity instituted in a district court of the United States for a district in which some part of the project is situated, and in the manner provided in the Act: (*a*). In case construction of the project works covered by the license, or of any specified part thereof, has been begun but not completed within the time prescribed in the license, or as extended by the Commission; or (*b*) in case the terms of the license are violated by the licensee.

Plans for A.S.M.E. Annual Meet

Meeting in New York December 7-10 to Consider Vital Transportation Problem—Newly cations to Woodworking and a Number of

THE tentative plans for the Forty-first Annual Meeting of The American Society of Mechanical Engineers to be held in New York early in December are prophetic of the best meeting in the history of the Society. The main points which assure success lie in the importance of the topic selected for the Keynote Session and in the fine spirit of coöperation shown by the newly formed Professional Sections, which will present many valuable and interesting papers.

Keynote Session

Transportation will be the subject of the Keynote Session. Industry in this country is being severely handicapped because of the lack of adequate transportation facilities, and from present indications it will take several years for these facilities to catch up with the increased traffic and the normal development which will take place within the next few years.

Several phases of the transportation question will be considered on a broad, economic basis and with a view to developing practical constructive measures for improving the conditions. Addresses will be made on the railroad situation; water transportation, including rivers, lakes and canals; motor-truck transportation; terminals and freight handling; the Greater New York transportation problem; the development of railroad feeders; and a general address in the nature of a résumé or study of the whole transportation question in a large way.

Sessions of the Professional Sections

Six of the newly formed Professional Sections have presented plans for vitally interesting sessions at this meeting. This mobilization of engineering skill for the discussion of the problems in the various subdivisions of mechanical engineering has greatly increased the value of the meeting.

Fuel Section

The fuel situation of the United States demands careful attention by every individual, and help in conservation can be secured only by application of engineering principles. These points are clearly brought out in the four papers to be presented by the Fuel Section at the Annual Meeting, the following abstracts of which indicate the broad view-points of the authors.

The Fuel Supply of the World, by L. P. Breckenridge.[1] This paper presents the latest available data on supply, production and use of various fuels of the world, particularly of the United States. It dwells primarily on supplies of various kinds of coal: anthracite, bituminous, lignite and peat. The problems of diminishing supply of natural gas and oil are discussed. The writer also touches on the evident impossibility of ever developing any considerable amount of water power in proportion to the total power requirements of that portion of the United States lying east of the Mississippi River. The paper closes with a plea for thrift in the use of coal, setting forth how in a broad way the waste of fuel may be prevented.

Fuel Conservation, by David Moffat Myers.[2] The results secured by the constructive conservation of fuel during the war, a program based on hurriedly formed and necessarily imperfect plans, are an indication of what might be accomplished by thorough and complete plans for constructive conservation in peace time. Some of the main items of waste to be considered are found in (1) boiler plants; (2) coke ovens; (3) domestic heating equipment; and (4) plants and installations misusing steam after its generation. Under the last item the author considers the waste of exhaust steam. He emphasizes the need for coöperation between the private plants needing both heat and power and the central stations, which could supply both instead of wasting some 80 per cent of the heat of the steam into the condenser. In the case of the private plants producing a surplus amount of exhaust steam, more power might easily be generated and sold to the central-station system. Fuel conservation, the author states, can never be satisfied by development of the central-power-plant idea alone; the privately owned plant is essential to economy.

Touching on the "superpower" system advocated by W. S. Murray and included in a footnote to the paper, Mr. Myers believes that the plan as applied to railroads alone would have many important advantages but that in industrial and building heating the waste of steam and fuel in large central stations would be augmented rather than reduced.

Mr. Myers believes that the need of a definite policy of fuel conservation is urgent. Natural gas is practically gone, it is estimated that the supply of natural fuel will be exhausted in 20 to 30 years, and coal, first anthracite and then bituminous, our last natural fuel resource, will be the next to disappear. The author advocates educating the public to the point where it will demand the coöperation of the Government in the conservation of fuel, and in conclusion he presents for consideration and constructive criticism a policy of fuel conservation to be adopted with the coöperation of the Government.

Distillation of Fuels as Applied to Coal and Lignite, by O. P. Hood.[1] The necessity for conservation of both capital and raw material are two important factors restricting the distillation of coal. On the other hand, coal distillation is encouraged by the hope that if elements of higher value are recovered from coal by distillation, the remaining fixed carbon can be sold at a price lower than the raw fuel and also that by extensive distillation and other processes, manufactured gas may reinforce our rapidly disappearing natural gas.

Among the processes of distillation which are receiving considerable attention is that resulting from low temperature. The most advanced experiment in this country using low-temperature carbonization and distillation is the carbocoal process. In the production of metallurgical coke, distillation of coal in by-product coke ovens is already the major process.

The most favorable field for the expansion of distillation processes lies in domestic heating service. In lignite areas of the United States where there are large supplies of low-grade fuel and eastern coals are obtained with difficulty, experimental work has shown the possibility of applying distillation methods to this fuel, obtaining gas, tar, ammonium sulphate and a carbonized residue of excellent heating value.

Form Value of Energy in Relation to its Production, Transportation and Application, by Chester G. Gilbert[2] and Joseph E. Pogue.[3] Resource energy, as the source of power, heat, and chemical work, is the basis of industrial activity and social advancement. The quantity of energy required in the United States has grown to such stupendous size that its provision in the customary form is becoming increasingly difficult, as reflected in uncertainties of supply and rising cost. Coal, oil and water power—the major sources of energy—need each to be considered in regard to production, transportation and utilization; hence the problem assumes at once the complexity of a mathematical function with nine variables. The field of energy is an economic and technologic checkerboard, no area of which can be measured or appraised without due regard to all its associated components.

The energy situation is therefore reviewed in this paper from two points of view, that of "form value," defined as an intangible quality expressing the broad applicability of the energy form in contrast to its theoretical thermal value as commonly expressed in B.t.u. units; and "resource value," defined as an intangible quality expressing the availability of energy in terms of location and chemical character of its source, and involving the potentiality of chemical control for purposes of multiple production. Form value, in respect to both application and transportation, and resource value are discussed as basic factors in the development of a balanced energy supply. Industrial analogies contained in the paper furnish the reader with practical applications of the theory set forth.

Railroad Section

In preparing its program the Railroad Section desires to bring to bear the combined skill of its members in the advancement of ideas and information that will be of benefit to all railroad men of the country in the solution of their immediate problems. The program includes the papers which are abstracted below and gives ample opportunity for the discussion of situations through which railroad problems must pass before solution.

Modernizing Locomotive Terminals, by G. W. Rink.[4] This paper is a discussion of the problem of providing adequate facilities for the proper maintenance of locomotives at engine terminals. The location, size and general layout is dependent on various elements, the two principal factors being character of work to be performed and location of the general locomotive repair shop. The necessity for

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ing Assure Phenomenal Success

**Organized Professional Sections Have Planned Interesting Sessions—Engineering Appli-
Strong Miscellaneous Papers to be Presented**

providing modern facilities is discussed with a view of awakening an interest in this subject, which has an important bearing on the ability of the railroads to handle the increased traffic demands of the country. The introduction of modern labor-saving facilities not only makes for economy in repairs, but shortens the time necessary to prepare locomotives for service. The various structures which comprise the terminals are treated separately with more or less detail, having in mind that the entire problem must be handled in such a way that it will be of service in modernizing existing locomotive terminals as well as to provide information of value in designing new terminals.

Increasing the Capacity of Old Locomotives, by C. B. Smith.[1] The high cost of railroading makes this subject of increased importance at the present time. The usual policy with reference to the purchase of new locomotives and the conversion of old ones is not, in the opinion of the writer, a well-formulated policy. The difficulty lies in the fact that shop facilities are inadequate, a large amount of both time and money being consumed unnecessarily. The problems of adapting the old-type locomotives to suburban and local service are discussed and the items which are to be considered in any program for increasing locomotive capacity are listed. Mr. Smith cites examples of satisfactory reconstruction which justify the improvement program advocated by him, and states that the application of all the desirable auxiliaries to old engines is prohibitive without a radical provision for carrying out such a program.

Adjustment of Vehicles on Curves, by R. Eksergian.[1] The author gives a suggested outline of important factors that should be con-

[1] Mechanical Engineer, Boston, Mass.

[1] Engineer, Baldwin Locomotive Works, Philadelphia, Pa.

TENTATIVE ANNUAL MEETING PROGRAM

New York, December 7–10, 1920

(Other subjects or changes to be announced later)

Tuesday Afternoon, December 7 (Simultaneous Sessions)

FUEL SECTION

- Fuel Supply of World, L. P. Breckenridge
- Low-Temperature Distillation of Coal, O. P. Hood
- Fuel Conservation Versus Money Conservation, D. M. Myers
- Form Value of Energy in Relation to Its Production, Transportation and Application, Chester G. Gilbert and Joseph E. Pogue

WOODWORKING SECTION

- Engineering in Furniture Manufacture, B. A. Parks
- Use of Wood for Freight Cars, H. S. Sackett
- Woodworking Educators, F. F. Moon
- Wooden Hollow Ware, John L. Graham
- Wooden Factory Flooring, L. T. Erickson
- Wood Preservation, E. S. Park and J. M. Webber
- Electrically Operated Sawmills, A. E. Hall

MACHINE-SHOP SECTION

- Side Cutting of Thread Milling Hobs, Earle Buckingham

Tuesday Evening, December 7

Report of Tellers of Election and Introduction of the President-Elect
Presidential Address
Conferring of Six Honorary Memberships
Presidential Reception and Dance

Wednesday Morning, December 8

Business Meeting. Amendments to the Constitution, Reports of Standing Committees, Committees on Code of Ethics, Industrial Relations, Education, Feedwater-Heater Standardization, etc.

Wednesday Afternoon, December 8 (Simultaneous Sessions)

MANAGEMENT SECTION

- The Life and Work of the Late Henry L. Gantt
- An Appreciation from France, M. Ch. de Freminville
- An Appreciation from Great Britain, James J. Butterworth
- Mr. Gantt's Contribution to Industry, Fred. J. Miller, Pres. A.S.M.E.
- Mr. Gantt's Contribution to Shipbuilding, Ship Operation, Ordnance and Aircraft, Marshall Evans
- The Culmination of Mr. Gantt's Work, E. A. Lucey
- Mr. Gantt's Industrial Philosophy, W. N. Polakov

RAILROAD SECTION

- Static Adjustment of Trucks on Curves, R. Eksergian
- Increasing Capacity of Old Locomotives, C. B. Smith
- Modernizing Locomotive Terminals, George W. Rink

RESEARCH

- Calibration of Nozzles for the Measurement of Air Flowing into a Vacuum, Wm. L. DeBaufre
- The Heat-Insulating Properties of Cork and Lith Board, A. A. Potter, J. P. Calderwood, A. S. Mack and L. S. Hobbs
- The Flow of Fluids through Pipe Lines and the Effect of Pipe-Line Fittings, D. E. Foster
- Steam Formulae, R. C. H. Heck

Wednesday Evening, December 8

Brashear Memorial. Oration will be delivered on the life and work of the late Dr. John A. Brashear, Past-President, A.S.M.E.

Thursday Morning, December 9

Keynote Session on Transportation. The following phases of the Transportation Problem will be discussed by authorities in this field: Railroads; Waterways; Feeders; Motor Trucks; Terminal Problem of New York City

Thursday Afternoon, December 9

Continuation of Keynote Session on Transportation
Ladies' Tea and Dance

Friday Morning, December 10 (Simultaneous Sessions)

DESIGN

- Disastrous Experiences with Large Center-Crank Shafts, Louis Illmer
- Tests on Rear-Axle Worm Drives for Trucks, K. Heindlhofer
- Foundations for Machinery, N. W. Akimoff

TEXTILE SECTION

- Humidity Control in Textile Plants, Author to be announced
- Power Application to Finishing Plants, Leo Loeb
- Textile Fabrication for Mechanical Purposes, J. W. Cox

POWER SECTION

- Session Devoted to Consideration of Future Developments of Power

MISCELLANEOUS

- The Constitution and Properties of Boiler Tubes, A. E. White

Other Papers to be Scheduled Later

sidered in the layout of a locomotive from the aspect of the adaption of the running gear to a plane curve. The paper considers in detail the following points: (*a*) The geometrical limitations imposed for a given curve with a proper wheelbase and the relation between lateral play and length of wheelbase, etc.; (*b*) the nature of the lateral reactions induced between the various elements of the running gear for various wheel arrangements and curves; (*c*) the elementary requirements in the design layout and arrangement of the wheelbase, together with the proper type of guiding trucks, etc.; and (*d*) the effect of the lateral reactions on the running gear as to strength of axles, etc.

Management Section

The program of the session of the Management Section has been drawn up with the purpose of summarizing the life work of Henry L. Gantt and crystallizing the principles thereof for the guidance of the engineer.

Of the speakers, President Miller has long been an apostle of management as expounded by Mr. Gantt and for several months previous to Mr. Gantt's death was associated with him. Mr. Evans served in the Emergency Fleet Corporation during the war and there had an opportunity to give Mr. Gantt's methods a thorough tryout. Mr. Polakov was intimate with Mr. Gantt and is able to successfully interpret the fundamentals of his philosophy. Mr. Lucey was long a member of Mr. Gantt's organization and directly in touch with his latest plans. Messrs. Butterworth and de Freminville were close students and great admirers of his life and work. The session will have an appeal not only to the disciples of Mr. Gantt but to every engineer in industry, for the engineer has been the first to realize that the industrial problem is a problem of "man," and the understanding is now general that Mr. Gantt was the pioneer in applying the humanizing influence to management problems.

Machine Shop Section

Papers on important points in machine-shop practice will be discussed, and although the valuable paper by Earle Buckingham on the subject Side-Cutting of Thread-Milling Hobs is the only one at present selected by the Committee, we are assured that other valuable contributions will be received which will make up a particularly strong session.

Textile Section

Although this Section has not been formerly organized, its members have shown great interest, and the session to be held at the Annual Meeting will bring out four papers of practical value to the textile manufacturers.

Power Section

At the time of going to press the plans for this session had not been entirely completed. However, the subject for discussion will be Future Power Developments. Its treatment will be from four points of view, as follows:

(*a*) The Policy of Future Power Development, covering broad general aspects of future development and placing emphasis on fuel conservation and elimination of uneconomical generating stations.
(*b*) Effect of Load Factors on Cost, dealing with the economy in operating and capital charges due to diversity of load factors.
(*c*) Effect of Size of Plant on Cost, treating of high economies possible in large plants.
(*d*) Financial and Legal Aspects of Future Power Development.

Miscellaneous

As has been announced previously in Mechanical Engineering, a session will be devoted to the discussion of the Principles of Engineering in Woodworking. This session will give detailed information as to the proper application of engineering to varied subjects of the woodworking industry, and will emphasize the great need for further application of engineering principles to this industry.

In addition to the miscellaneous Annual Meeting papers, copious abstracts of which are included in this issue of Mechanical Engineering, there will be presented a paper by N. W. Akimoff containing a detailed discussion of Foundations for Machinery. Mr. Roger M. Freeman will also present a paper giving the general layout of the $20,000,000 Naval Ordnance Plant at Charleston, W. Va.

Brashear Memorial

The greatness of Dr. John A. Brashear is worthy of fitting tribute by The American Society of Mechanical Engineers. With this in mind, Wednesday evening of the meeting week has been set aside for the honoring of a great man. An oration setting forth in form for permanent record the lovable qualities and successful attributes of "Uncle John" will be presented.

Thursday Evening

Attention is especially called to the action of the Meetings Committee in not scheduling a meeting event on Thursday evening. This program permits the holding of College reunions on Thursday night if desired and gives out-of-town members attending the meeting an opportunity to avail themselves of some of the various amusements which the metropolis offers.

History of Naval Consulting Board Just Issued

The Navy Department has just issued a 288-page book containing a history of the origin and accomplishment of the Naval Consulting Board. Created in 1915 by the Secretary of the Navy and headed by Thomas A. Edison, this organization played a conspicuous part in the development of war inventions and new devices.

The formation of the Board, it will be recalled, was effected with the aid of the national engineering and allied techinal organizations, who selected from their membership men especially qualified to form the personnel of such an important body. The American Society of Mechanical Engineers, for example, were represented by W. R. L. Emmet, a consulting engineer of the General Electric Company and Spencer Miller, of the Lidgerwood Manufacturing Company, whose work has been largely concerned with the design and production of marine apparatus.

The history of the Board was written by Lloyd N. Scott, late Captain, U. S. A., who acted as liaison officer to the Board and the War Committee of Technical Societies from the Invention Section of the General Staff, U. S. A. Special emphasis is laid on the fuel-oil investigation, the new naval station on the Pacific Coast, ship protection, the inventive accomplishments of the members of the board, and the meritorious inventions received from the public. Many of the special problems on which the Board worked in close coöperation with Army and Navy officials are also reviewed.

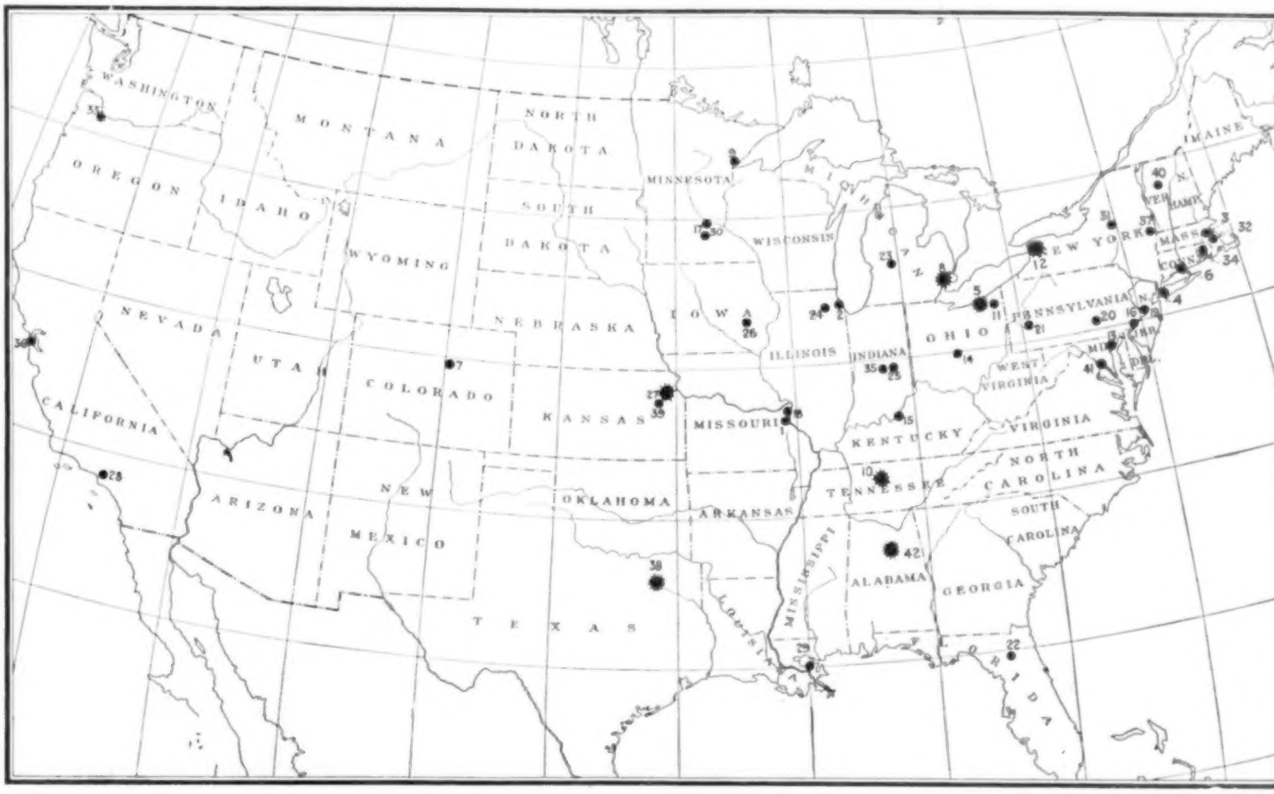
The preface to the volume comes from the pen of Secretary Daniels, who writes of the work of the Board in the following words:

> It would have been impossible for the Navy to have carried on its efficient part in winning the World War without the intelligent and patriotic contribution of civilian thinkers and workers as well as civilians who enlisted in every department of naval effort. Foremost among these civilian patriots stand the members of the Naval Consulting Board. Its members gave themselves fully to the service of their country, bringing scientific and engineering knowledge, with large experience touching the vital problems that confronted the Navy. The membership of this Board was chosen by and from the foremost engineering societies in America, embracing men whose achievements were of world renown. The Navy, indeed the whole country, owes their scientific patriotism a debt not only for what they wrought but quite as large a debt for the stimulus and inspiration they imparted to the naval personnel and to civilians enlisted in national service.

The Astoria Silk Mills of Astoria, L. I., have recently purchased the historic West Point Foundry, in Cold Spring, and will operate it with 700 employees. The foundry closed down a few years ago, after the A. B. & J. M. Cornell Iron Works had operated it for several years. The first locomotive used in New York State, the old wood burner De Witt Clinton, now on exhibition in Grand Central Terminal, was constructed there. The plant was rushed with war orders during the civil war making hundreds of Parrott guns.

The Federated American Engineering Societies Was Created To Consolidate The Engineering Organizations of America

Is Your Engineering Society a Member of This Federation?



THE FIELD OF THE FEDERATION
Circles Show Local Societies Represented at Washington Conference, June 3 and 4, 1920
Asterisks Show Local Societies Now Members of the Federation

Last June delegates from 30 national and 41 local and regional organizations met and created THE FEDERATED AMERICAN ENGINEERING SOCIETIES. It is a going organization and on November 18 and 19 the first meeting of its governing body, the American Engineering Council, will be held at Washington, D. C. Will your Society be represented? Consult the list below and see. The societies listed in bold-face type are those which are now members of the Federation.

ORGANIZATIONS REPRESENTED AT WASHINGTON CONFERENCE, JUNE 3 AND 4, 1920

LOCAL, STATE, AND REGIONAL ORGANIZATIONS

(1)	Associated Engineering Societies of St. Louis, St. Louis, Mo	1,200
(2)	Associated Engineers of Spokane, Spokane, Wash	200
(3)	Boston Society of Civil Engineers, Boston, Mass	786
(4)	Brooklyn Engineers' Club, Brooklyn, N. Y	415
(5)	**Cleveland Engineering Society, Cleveland, Ohio**	**1,300**
(6)	Connecticut Society of Civil Engineers, New Haven, Conn	385
(7)	Colorado Society of Engineers, Denver, Colo	415
(8)	**Detroit Engineering Society, Detroit, Mich**	**575**
(9)	Duluth Engineers' Club, Duluth, Minn	154
(10)	**Engineering Association of Nashville, Nashville, Tenn**	**125**
(11)	Engineering Society of Akron, Akron, Ohio	436
(12)	**Engineering Society of Buffalo, Buffalo, N. Y**	**600**
(13)	Engineers' Club of Baltimore, Baltimore, Md	230
(14)	Engineers' Club of Columbus, Columbus, Ohio	250
(15)	Engineers' and Architects' Club of Louisville, Louisville, Ky	225
(16)	Engineers' Club of Philadelphia, Philadelphia, Pa	2,222
(17)	Engineers' Club of Minneapolis, Minneapolis, Minn	179
(18)	Engineers' Club of St. Louis, St. Louis, Mo	625
(19)	Engineers' Club of Trenton, Trenton, N. J	280
(20)	Engineers' Society of Pennsylvania, Harrisburg, Pa	702
(21)	Engineers' Society of Western Pennsylvania, Pittsburgh, Pa	1,200
(22)	Florida Engineering Society, Gainesville, Fla	162
(23)	Grand Rapids Engineering Society, Grand Rapids, Mich	85
(24)	Illinois Society of Engineers, Wheaton, Ill	262
(25)	Indiana Engineering Society, Indianapolis, Ind	225
(26)	Iowa Engineering Society, Iowa City, Iowa	358
(27)	**Kansas Engineering Society, Topeka, Kansas**	**205**
(28)	Los Angeles Joint Technical Society, Los Angeles, Cal	1,600
(29)	Louisiana Engineering Society, New Orleans, La	285
(30)	Minnesota Surveyors' and Engineers' Society, Minneapolis, Minn	200
(31)	Mohawk Valley Engineers' Club, Utica, N. Y	160
(32)	New England Water Works Association, Boston, Mass	890
(33)	Oregon Technical Council, Portland, Ore	330
(34)	Providence Engineering Society, Providence, R. I	830
(35)	Scientech Club, Indianapolis, Ind	120
(36)	San Francisco Joint Council of Engineering Societies, San Francisco, Cal	1,600
(37)	Society of Engineers of Eastern New York, Troy, N. Y	490
(38)	**Technical Club of Dallas, Dallas, Texas**	**125**
(39)	Topeka Engineers' Club, Topeka, Kansas	63
(40)	Vermont Society of Engineers, Montpelier, Vt	150
(41)	Washington Society of Engineers, Washington, D. C	482
(42)	**Alabama Technical Association, Birmingham, Ala**	**110**

NATIONAL ORGANIZATIONS

(1)	American Association of Engineers, Chicago, Ill	20,000
(2)	American Association of Petroleum Geologists, Norma, Okla	250
(3)	American Ceramic Society, Alfred, N. Y	1,262
(4)	American Concrete Institute, Boston, Mass	450
(5)	American Electric Railway Engineering Association, New York, N. Y	800
(6)	American Electrochemical Society, Bethlehem, Pa	2,500
(7)	**American Institute of Chemical Engineers, Brooklyn, N. Y**	**318**
(8)	**American Institute of Electrical Engineers, New York, N. Y**	**11,345**
(9)	**American Institute of Mining and Metallurgical Engineers, New York, N. Y**	**8,689**
(10)	American Railway Engineering Association, Chicago, Ill	1,450
(11)	American Society of Agricultural Engineers, Columbus, Ohio	624
(12)	American Society of Civil Engineers, New York, N. Y	9,652
(13)	**American Society of Mechanical Engineers, New York, N. Y**	**12,705**
(14)	American Society of Refrigerating Engineers, New York, N. Y	400
(15)	American Society of Safety Engineers, New York, N. Y	456
(16)	American Society of Heating and Ventilating Engineers, New York, N. Y	1,203
(17)	American Society for Testing Materials, Philadelphia, Pa	2,765
(18)	American Water Works Association, New York, N. Y	2,616
(19)	Association of Railway Electrical Engineers, Chicago, Ill	450
(20)	Illuminating Engineering Society, New York, N. Y	1,250
(21)	Institute of Radio Engineers, New York, N. Y	1,600
(22)	Mining and Metallurgical Society of America, New York, N. Y	305
(23)	National Fire Protection Association, Boston, Mass	3,203
(24)	National Safety Council (Engineering Division), Chicago, Ill	200
(25)	Society of Automotive Engineers, New York, N. Y	4,869
(26)	**Society of Industrial Engineers, Chicago, Ill**	**400**
(27)	Society of Naval Architects and Marine Engineers, New York, N. Y.	1,688
(28)	Society of American Military Engineers, Washington, D. C	1,600
(29)	Society for the Promotion of Engineering Education, Pittsburgh, Pa.	1,525
(30)	Taylor Society, New York, N. Y	370

Engineering Division of National Research Council Issues Report

Research in the Future to be Conducted by a Special Committee in Each Field—Reorganization of Division Opens Way for Greater Coöperation with Industries and Engineering Organizations—Grouping of Existing and Proposed Committees

THE Division of Engineering of the National Research Council recently rendered to Engineering Foundation, which coöperates with it in its work, a report of its accomplishments to date and the lines along which it expects to develop in the immediate future. As in the case of many other fields of endeavor, engineering research has been greatly handicapped by lack of funds, and Comfort A. Adams, chairman of the Division, emphasizes this fact in his report. He writes:

> The opportunities for service of great importance to our industries and to our country are almost appalling in number; but although the past accomplishments of our committees constitute a very considerable contribution toward such service, the progress in any particular case must be discouragingly slow, without substantial financial support. For example, the very substantial accomplishment of the Welding Committee was due in considerable part to the financial support of the Emergency Fleet Corporation, amounting to over $40,000 for one year. If all of our committees were supported on this same scale, by contributions from the interested industries, the annual contribution of any one company would be less than they pay in advertising during one month, and utterly insignificant as compared to the value of the results, as was true in the case of the Welding Committee.

Despite this lack of adequate funds, the Division has carried on research in many fields, and that its future undertakings may be productive, the work now in progress is being reorganized on the group basis; that is, in each general field there will be a General Advisory Committee, with a small, active Executive Committee, under which will be organized the several Research Committees. These General Advisory Committees will also be the agencies through which the Engineering Division will endeavor to stimulate the industrial world to conduct the more commercial forms of research. Furthermore, in order to enlist the active coöperation of the engineering societies, it is hoped to have each society accept as its own research committee the Advisory Committee in its particular field.

The grouping of the existing committees and of those in formation is shown in the accompanying chart. The first group (S) is largely made up of committees organized by Dr. H. M. Howe, formerly chairman of the Division, either during or shortly after the war. Several other committees of this group organized specially for war work, completed their work and were discharged. The committees on Non-Ferrous Metals (NF), Fatigue Phenomena of Metals (F), New Hardness-Testing Machine (HT), and Pulverizing (P), were likewise organized by Dr. Howe, and some of these might have been included in the Steel group, except that they apply also to non-ferrous metals.

All of these committees naturally come within the field of mining and metallurgy, and although they are not at present recognized as officially connected with the American Institute of Mining and Metallurgical Engineers, Professor Adams states in his report that it is expected they will be coördinated in the near future under a general group committee of that Institute.

It is similarly expected that the Electrical Group (E) and the Highway Group (H) will probably be accepted by the American Institute of Electrical Engineers and the American Society of Civil Engineers, respectively. None of the three societies mentioned above has research committees of its own. On the other hand, however, the group dealing with Mechanical Engineering (M) was organized by The American Society of Mechanical Engineers and is being administered and financed by that society.

The Alloy Research Association (AR) was first fathered by the Division of Research Extension and was intended to be an organization of the interested industries and, after it was well started, largely independent of the National Research Council. At present, however, its activities are confined to an information service and its management is attached to the National Research Council, the Engineering Division coöperating in this work.

The Society of Automotive Engineers is very much alive to the importance of research, but although some work has been done under its technical committees, the society is just now feeling its way in respect to the organization and conduct of research.

The Society of Heating and Ventilating Engineers is also actively engaged in research, most of its work being done at the Bureau of Mines' Pittsburgh Laboratory, under the direction of Prof. John R. Allen. The society has collected more than $20,000 per year from the industries for the conduct of this coöperative research, and the Bureau of Mines contributes space, facilities and assistance of about equal value. Several researches are actively under way at the present time.

The Society of Refrigerating Engineers is likewise thoroughly alive to the need for research, and although it has no research committee, it has appointed Professor Rautenstrauch, of Columbia University, as its representative on the Division, and he is now organizing for research in this field.

Engineering Division N.R.C.

- S-Steel (Metallurgy) (Advisory Committee A.I.M.E.)
  - S-1 Elimination of Inclusions
  - S-2 Elimination of Sulphur and Phosphorus
  - S-3 Heat Treatment
  - S-4 Physical Changes below the Thermal Critical Range
  - S-5 Substitute Deoxidizers
  - S-6 Steel Ingots
  - S-7 Neumann Bands
  - S-8 High-Speed Tool Steels
  - S-9 Effect of Sulphur and Phosphorus (Joint Committee under A.S.T.M.)
  - S-10 Magnetic Analysis of Steel (Representative on A.S.T.M. Comm. A-8)
- AR-Alloys Research Association (In cooperation with Division of Research Extension, N.R.C.)
- NF-Non-Ferrous Metals
  - N.F-1 Uses of Tellurium and Selenium
  - N.F-2 Uses of Cadmium
- F-Fatigue Phenomena of Metals (Engineering Foundation)
- HT-New Hardness-Testing Machine
- P-Pulverizing
- E-Electrical (Advisory Committee A.I.E.E.)
  - E-1 Insulation
  - E-2 Core Loss
  - E-3 Radio Research
  - E-4 Heating of Electrical Machinery
- H-Highway
  - H-1 Economic Theory of Highway Improvements
  - H-2 Structural Design of Roads
  - H-3 Properties and Uses of Highway Materials
- M-Mechanical Engineering (A.S.M.E. Research Committee)
  - M-1 Lubrication
  - M-2 Bearing Metals
  - M-3 Heat Transfer
  - M-4 Cutting Action of Cutting Tools
  - M-5 Permanency and Accuracy of Engineering Instruments
- A-Automotive Engineering (S.A.E.)
- HV-Heating and Ventilating (A.S.H.& V.E.)
- R-Refrigeration (A.S.R.E.)
- W-American Bureau of Welding (American Welding Society)
  - W-1 Electric Welding
  - W-2 Gas Welding
  - W-3 Welding of Pressure Vessels (Cooperating with Boiler Code Committee of A.S.M.E.)
  - W-4 Welding of Storage Tanks

Finally, the American Bureau of Welding of the American Welding Society is also about to be reorganized as the General Advisory Committee on Welding to the Division of Engineering, although at present the research committees of the Bureau are officially committees of the Division.

CALIBRATION OF NOZZLES

(Continued from page 609)

greater the amount of moisture, the less the total weight of fluid that flows through the nozzle in a given time. Thus, when air flows through a nozzle from the atmosphere, the usual variations which occur in the amount of moisture contained therein produce appreciable changes in the weight of dry air admitted in a given time.

Based on an expansion exponent of $n = 1.375$, the rates of flow of dry air containing no moisture under the normal conditions of 70 deg. fahr. and 29.92 in. mercury pressure, 0.07492 lb. per cu. ft. density, have been calculated for the nozzles, calibrated, and are tabulated in Table 1.

Engineering and Industrial Standardization

The Standardization of Safety Codes

DURING the past ten or fifteen years many states have passed laws providing for the compensation by employers of workmen injured while engaged in the duties of their various occupations. These laws are administered by the state boards, usually called industrial accident boards or compensation commissions, and an organization of these boards has been formed called the International Association of Industrial Accident Boards and Commissions.

Some of these boards have not only administered the state laws respecting compensation but have also issued safety rules for use by the industries of their respective states. Such work is of great importance. Only a few states, however, have funds and technical staffs sufficient to independently prepare safety rules or codes and hence some states copy the rules of others with such changes as seem necessary or advisable, and promulgate them with such instructions and supervision as they are able to give. These rules are revised from time to time to make them more complete, and thus as each state has prepared and revised them considerable divergence has occurred, which has often proved embarrassing to manufacturers furnishing machinery and supplies which are expected to comply with the requirements of states having such rules.

As a step toward the elimination of this duplication the Bureau of Standards coöperated during the war with the War and Navy Departments in the preparation of several industrial safety codes for the use of the Government establishments. Furthermore, in order to get the judgment of all those most active in such work, the Bureau called a conference of approximately 100 organizations interested in safety codes. This conference was held in Washington, January 15, 1919. The special question put before it was how the work of preparing safety codes could be carried out so that they might become national and be generally used throughout the country. The suggestion was made that codes be submitted for the approval of the recently organized American Engineering Standards Committee, and at a second conference held on December 8, 1919, a resolution was passed that safety codes for general use should be prepared according to the procedure of that body.

A second resolution requested the American Engineering Standards Committee to ask the International Association of Industrial Accident Boards and Commissions, the National Safety Council, and the Bureau of Standards to form a Joint Safety Code Committee which should prepare a report giving a list of safety codes which should be prepared and recommending sponsors for the same. On January 3, 1920, the American Engineering Standards Committee took favorable action upon this request and formally asked these three organizations to form a committee.

This Joint Safety Code Committee was organized as an advisory committee to the American Engineering Standards Committee and has rendered valuable service. In its reports so far it has recommended the sponsorships for thirty-seven safety codes. Recent activities of a number of these sub-committees are given below.

Safety Code on Power Presses. The National Safety Council which has been assigned by the American Engineering Standards Committee the sponsorship for the Safety Code on Power Presses, has requested The American Society of Mechanical Engineers to appoint two representatives to serve on the Sectional Committee. The Society appointees are E. E. Barney, development engineer, Remington Typewriter Company, New York City, and C. N. Underwood, executive secretary of the Clothiers' Exchange of Rochester.

Safety Code for Grinding Machinery. The American Engineering Standards Committee has assigned to the Grinding Wheel Manufacturers' Association of the United States and Canada, and the International Association of Industrial Accident Boards and Commissions, the sponsorship for a Safety Code for Grinding Machinery. At the request of the Grinding Wheel Manufacturers' Association, Walter B. Gardiner, mechanical superintendent, Lincoln Twist Drill Co., Taunton, Mass., has been appointed to serve on this Committee.

Safety Code on Paper and Pulp Mills. The National Safety Council as sponsor for this code has requested The American Society of Mechanical Engineers to appoint two representatives to serve on this Committee.

Safety Code on Logging and Sawmill Machinery. The Bureau of Standards was appointed sponsor by the American Engineering Standards Committee to formulate a Safety Code on Logging and Sawmill Machinery. The Bureau of Standards has requested The American Society of Mechanical Engineers to designate a representative to serve on the Sectional Committee, and Joseph H. Dickinson, engineer, Lidgerwood Manufacturing Company, New York City, has been appointed.

Mechanical Transmission of Power. The International Association of Industrial Accident Boards and Commissions, the National Workmen's Compensation Service Bureau, and The American Society of Mechanical Engineers have been appointed joint sponsors for the Safety Code for the Mechanical Transmission of Power. The A.S.M.E. has designated the following members to serve on this Committee: A. C. Jewett, Winchester Repeating Arms Company, New Haven, Conn.; F. L. Morse, Morse Chain Company, Ithaca, N. Y.; G. M. Naylor, Fairbanks Company, New York City; R. W. Sellew, The Fafnir Bearing Company, New Britain, Conn.; E. D. Wilson, Graton & Knight Manufacturing Company, Worcester, Mass.; D. C. Wright, Dodge Manufacturing Company, Mishawaka, Ind.

International Aircraft Standardization

One of the most important organizations now concerned with standardization is the International Aircraft Standards Commission. This Commission is composed of representatives of Canada, France, Great Britain, and Italy. The admission of Belgium and Japan awaits formal confirmation, and needless to say the participation of America is greatly desired. The next meeting of the Commission will be held in Paris during November, and for the purpose of discussing America's participation therein a meeting was recently held in Washington, D. C., which was attended by the representatives of Government departments and national engineering organizations.

The meeting was called to order by A. A. Stevenson, chairman of the American Engineering Standards Committee, who stated that the organization which he represented had been requested to arrange for unofficial American representation at the Paris meeting of the Commission, if it were found impossible to secure full and official representation. Mr. Stevenson also stated that the Commission is planning to consider at the November meeting such general matters as the advisability of continuing on its present lines, its relation to whatever organizations should be set up by the Air Convention, and the consideration of reviewing or modifying the references to the Advisory Technical Committee.

After a full discussion of various methods which were proposed for bringing the matter to the attention of the proper Government officials, and what method should be followed in case Government credentials could not be secured, resolutions were unanimously passed authorizing the chairman to appoint a committee of not to exceed five to call on the chairman of the Council of National Defense and to present through him to the President a request for the authorization of official representation at the Paris Conference. The committee of five was also authorized to recommend in the event of favorable consideration of the request for official representation, that the American Engineering Standards Committee nominate members of the delegation who should represent this country.

The conference also went on record as favoring unofficial representatives, in the event that official representation cannot be secured, provided such a delegation would be permitted to sit in at the meetings of the International Commission, participate in the discussion, and be entitled to the report of the proceedings. It is also the sense of the conference that the American Engineering Standards commission, acting on behalf of the Conference, should appoint unofficial representatives.

NEWS OF THE ENGINEERING SOCIETIES

The Ninth Annual Safety Congress—Meetings of the Iron and Steel Electrical Engineers, American Society for Steel Treating, and American Chemical Society —The Sixth Chemical Exposition

Ninth Annual Safety Congress

That safety must be incorporated into the civic and school life and organized as a community activity is the 1920 slogan of the National Safety Council, under whose auspices the Ninth Annual Safety Congress was held in Milwaukee, September 27 to October 1. Over three thousand men and women delegates attended the congress. Two hundred exhibits in Mechanics' Hall showed every safety device on the market. The nineteen divisions of the council held sectional meetings, the sessions including those of engineering, public utilities, steam railroads, electric railroads, mining, rubber, metals, and the automotive industries. Motion-picture films on safety subjects were shown in the Milwaukee Auditorium during the days of the congress. Actual demonstrations by boy scouts of accident scenes which the safety workers had pictured verbally to the delegates, closed the program. From the point of view both of number of speakers and importance of the subjects discussed, this gathering was the most important in the history of the Council. Making safety a part of the instruction in public schools is the work upon which the Council plans to concentrate its energies in the immediate future. It is expected that the factory operative will thus have learned the principles of safety at an early age, and will be influenced by the instruction throughout his life.

Association of Iron and Steel Electrical Engineers

Recent developments in electrically driven reversing mills were recorded at the fourteenth annual meeting of the Association of Iron and Steel Electrical Engineers, held at the Hotel Pennsylvania, New York, September 24. A paper by K. A. Pauley on the Electric Reversing Mill Considered from the Standpoint of Tonnage gave an analysis of records on comparative runs in electric and steam mills showing that the electric mill can produce a tonnage equal to or greater than the steam mill. Coupling these records with the advantages of the electric mill from the standpoint of lower power costs, lower maintenance cost, greater flexibility of control, etc., there is little doubt that the steam reversing mill is now as out of date as the non-reversing steam mill has been for many years.

The educational committee suggested educating steel-mill electricians as to means for minimizing delays due to failure of electrical equipment in steel plants. Sample sheets of a practical electrical course being given to electricians in two large steel plants were included in the report of the committee.

The electric-furnace committee pointed out possible improvements in operating details of electric-furnace work. The report was prepared from answers received to a questionnaire sent out to steel manufacturers. The data secured indicate that the greatest need at present is for better electrode economy. Lack of tensile strength seems to be one of the difficulties of electrode trouble caused by the lines of cleavage of the calcined anthracite coal being in a vertical as well as horizontal direction, it being impossible at present to build an electrode where all the cleavage lines are horizontal. One of the chief sources of difficulty in furnace operation is delays due to handling material to and from the furnace. These can be reduced by bringing the scrap on the furnace floor from the rear and adjacent to the furnace in small cars on tracks and using traveling cranes entirely for handling the steel from the furnace.

In a paper on Some Economic Considerations in Design of Power Plants for Steel Mills, T. E. Keating studied in detail the utilization of blast-furnace gas and the efficiencies and costs that may be expected to prevail in such an installation. Power transmission was discussed by A. L. Freret in Underground Transmission, and by D. M. Petty in Transmission and Distribution of Power in Industrial Plants. A feature of the meeting was an exhibition on the roof of the hotel of representative types of electrical equipment for steel mills.

American Society for Steel Treating

The second annual convention of the American Society for Steel Treating was held in the Commercial Museum, Philadelphia, September 14–18, 1920, at which meeting the final steps of amalgamation between the Steel Treaters' Research Society and the American Steel Treaters' Society were consummated. Prof. A. E. White, of the University of Michigan, Ann Arbor, is president and W. H. Eisenman, of Cleveland, is secretary. The headquarters of the new society are at Cleveland.

The large floor space of the Commercial Museum was given over to an exhibition of various manufacturers of steel-treating devices and materials. A number of interesting sessions on the various phases of steel treating were held in the Assembly Hall. Among the noteworthy papers was that of H. P. MacDonald, vice-president, Snead & Co., Jersey City, N. J., who described a method of heat-treating aeroplane tubes by passing electric current through a tube to raise the temperature to the required degree, releasing the clamps holding the tube and allowing it to drop into the oil bath at the rate of one tube every 40 sec.

Dr. Charles W. Burrows, magnetic-research engineer, elaborated a method for the magnetic testing of rails, cables, etc., by which blowholes, flaws, seams, cracks, etc., would be revealed. Doctor Burrows showed that the method was commercial, inasmuch as only one minute was required per rail.

T. D. Lynch, of the Westinghouse Co., presented a tentative specification for the manufacture of helical springs required to transmit the power from a motor-driven quill, through a flexible coupling, to the driving wheels of a heavy electric locomotive. The analysis suggested is as follows: C, 0.50 to 0.60; Mn, 0.60 to 0.80; Si, 1.90 to 2.20; P, 0.04 max.; S, 0.04 max.

The properties of a highly resistant alloy steel were explained by Charles M. Johnson, director of research department, Crucible Steel Co. It is a complex alloy, with 0.3 to 0.4 per cent carbon, which reverts to a homogeneous solid solution upon annealing at 1300 deg. cent., and which, upon tempering being continued for several days, allows an excess constituent to divorce itself and become spheroidized. It is quite non-magnetic and resists staining and rusting remarkably. Although the metal can be forged, rolled or sheared in thicknesses 0.1 in. to 1 in., and is machinable, it offers a maximum resistance to prolonged heating at temperatures up to 2000 deg. fahr. and is cut by the oxy-acetylene torch with the utmost difficulty.

Metallurgical features of the manufacture of stainless steel articles were given by W. H. Marble, manager of American Stainless Steel Co. The analysis used is: C, 0.20 to 0.40; Cr, 13; Si, 0.30; Mn, 0.50. Chromium is the essential element furnishing the peculiar resistance to corrosion, tungsten and nickel being sometimes added for an increasing luster in polish. Ingots are box-annealed at 1380 deg. fahr., air-cooled, reheated to 2100 deg. fahr., and hammered carefully, never allowing the temperature to drop below 1650 deg. fahr. Cooling after forging gives hard material, the higher the uninterrupted cooling the harder becoming the material. Rough forgings are now reannealed at 1380 deg. fahr., using all the precautions necessary for high-grade steel, furnace-cooled to 1100 deg. fahr. and then air-cooled. This results in a Brinell hardness of 200. After machining and finishing the piece may be hardened from 1750 deg. fahr. in air, oil or water, depending upon the intricacy of the shape, and tempered at a suitable heat, varying from 280 deg. fahr. for knife blades to 1100 deg. fahr. for exhaust valves.

Other papers covered the Use of Quenching Fluids, the Development of Alloy Steels, and Various Fuels for Heat Treating, and symposiums were held which dealt with Case Carburizing and High-Speed Steel Treatment.

American Chemical Society

At the meeting of the American Chemical Society in Chicago, September 6 to 10, a fuel symposium was held at which a number of papers were presented of interest to mechanical engineers. The following notes on this session are abstracted from the report in *Power Plant Engineering* for October 1.

Dr. Harry A. Curtis described the process of manufacture of "carbocoal," the new smokeless fuel manufactured from bituminous coal and having certain of the characteristics of anthracite. It is prepared by crushing the soft coal and carbonizing it at the relatively low temperature of 900 deg. fahr. During the carbonization, which is carried out in a horizontal retort lined with carborundum, the coal is continuously stirred and moved slowly through the retorts by means of paddles mounted on steel shafts running lengthwise through the retort. A soft semi-coke is obtained from this low-temperature carbonization. The yield in tar is twice as much as is obtained from the ordinary coking process.

The semi-coke is ground, briquetted with pitch, and the briquets then carbonized for about six hours at 1800 deg. fahr. High-temperature carbonization renders the briquets hard, dense and smokeless. By-products are also obtained from the second carbonization. The first commercial plant manufacturing carbocoal was put into operation at Clinchfield, Va., in June 1920, and is equipped with 24 retorts giving a capacity of 500 tons of coal a day, from which 350 tons of the fuel are made. The process is the result of five years' experimental work at Irvington, N. J., and the large plant at Clinchfield was established as a war project.

Colloidal fuels were discussed by Dr. S. E. Sheppard. He recorded as a signal technical triumph the successful operation from April to July 1918, of the U. S. S. *Gem* on a colloidal fuel containing 30 per cent pulverized coal. Among the advantages he quoted for colloidal fuels were that they contain more heat units per gallon than fuel oils and very little moisture and ash, and that they are immune from spontaneous combustion and may be fireproofed by a "water seal" because they are heavier than water.

The development and increasing use of the by-product coke oven in the United States were dealt with by F. W. Sperr, Jr., and E. H. Bird. Before the war, coke was made largely in the simple beehive oven where tars run to waste and gases are discharged into the air. Now the by-product ovens lead the beehive ovens. The coking of a ton of high-grade coal in a beehive oven requires the consumption of 11,000 cu. ft. of gas, 9 gal. of tar, 4 gal. of light oil and 100 lb. of coke, which in all generate 9,388,000 B.t.u., or the equivalent of 671 lb. of coal. The by-product oven in making a ton of coke uses 4300 cu. ft. of gas, which is equal to 2,408,000 B.t.u., or equivalent to 172 lb. of coal.

Dr. J. B. Garner advocated the enrichment of illuminating water gas with natural gas as a means of economy. In this way, he said, natural gas could be so used as to insure to the public for many years to come a supply of gas at a cost at which it would otherwise be impossible to sell it.

Low-Temperature Carbonization and Its Application to High-Oxygen Coals, by S. W. Parr; Carbonization of Canadian Lignite, by Edgar Stansfield; Gasoline Losses Due to Incomplete Combustion in Motor Vehicles, by A. C. Fieldner, G. W. Jones and A. A. Straub; and Fuel Conservation, Present and Future, by Horace C. Porter, were subjects also considered at the fuel session.

Numerous other professional papers were presented at the other sessions. Attention may be called to the following: Electrometric Method for Detecting Segregation of Dissolved Impurities in Steel, by Edward G. Mahin and R. E. Brewer; Flow of Viscous Liquids Through Pipes, by Robt. E. Wilson and M. Seltzer; and Comparative Study of Vibration Absorbers, by H. C. Howard.

At the meeting of the council of the society the invitation to join The Federated American Engineering Societies and to send delegates to the coming meeting of the American Engineering Council was declined. It was held that the society should offer the Federation aid and encouragement, but that the fields of chemists and engineers were distinct and separate and that more and better work could be accomplished without interlocking the organizations in these branches.

Sixth Chemical Exposition

A multitude of products, comprising the most delicate instruments of precision, new chemicals and dyes, and a vast amount of machinery, displayed by nearly 500 exhibitors at the Sixth National Exposition of the Chemical Industries held in the Grand Central Palace, New York, September 20 to 25, afforded tangible evidence of the continued progress of the chemical and dye industries of the United States since the termination of the war. The exposition was formally opened with an address by Dr. Charles H. Herty, who said that during the past fiscal year our exports of chemicals totaled $1,250,000,000, of which $24,000,000 represented dye materials. Dr. Herty also outlined the growth of industrial research. Conservative estimates place the amount to be expended this year on industrial research laboratories, personnel, housing and equipment, at $25,000,000. He cited the example of a plant where industrial research had been instrumental in developing increased production, which suggested to him the possibility of overcoming the present inefficiency of labor through research on improved methods of operation in all lines of industry.

Dr. H. E. Howe, chairman of the Division of Research Extension, National Research Council, emphasized the fact that research plays a vital part in industrial conservation and cited the example of a certain mill in the application of modern bleaching methods. A reaction that was thought to take thirty hours for its completion was found to go forward under properly controlled temperature and pressure in three-quarters of a minute, so that but one-fifteenth of the capital was required to provide apparatus and stock formerly tied up in the process.

Dr. Howe also discussed the conservation of materials and the elimination of industrial waste through scientific control of processes. He related how steel mills were unable to make the type of billet which certain customers wanted until they had made their control more rigid. He took up, also, the question of protecting stores of both raw and finished products and again looked to scientific research for needed improvements. While much has been done there is still much more to be accomplished, and to this end the National Research Council has been organized with the coöperation of the national scientific and technical societies, many independent specialists, educational institutions and scientists employed by the Government.

Symposiums were held on fuel economy, industrial management, materials handling, chemical engineering and ceramics. Interest was enlivened by providing in connection with the papers extensive programs of motion pictures illustrating a wide range of chemical operations. R. C. Beadle, chairman of the Fuel Session, spoke on the duties and responsibilities of the combustion engineer in the present fuel crisis, and W. O. Rankin spoke on the use of pulverized fuel. Other papers at this session were: Saving Fuel by Controlling Chimney Losses, F. F. Uehling; Fluid Heat Transmission, Alexander B. McKechnie; Producer Gas and the Modern Mechanical Producer, W. B. Chapman; Refractory Cement: Life Insurance for a Furnace, F. W. Reisman; Preventing Conduction and Radiation Heat Waste, S. L. Barnes; Increasing Conduction and Reducing Fuel Consumption, W. R. Van Nortwick; The Reason for the Fuel Saving in the Dressler Kiln, Conrad Dressler.

The advance of the United States coal-tar chemical output in 1919 was recorded by Grinnell Jones, chief chemist, United States Tariff Commission. The productive capacity of the by-product coke ovens in the United States increased 17.2 per cent during 1919. With the possible exception of anthracene, adequate supplies of the fundamental raw materials of coal-tar origin will be available from American sources for the growth of the industry. The difficulty with anthracene is that its removal leaves the pitch so hard that it does not find a ready market under American conditions. Active work on the solution of this problem is now under way and the progress already made is encouraging. A comparison of the intermediates produced in 1918 and 1919 shows a considerable increase in the total number and substantial in-

crease in amount in many cases. In 1919 there were about 225 different intermediates produced, against about 140 in 1918.

The session on Materials Handling, of which Roy V. Wright, Chairmam Committee on Meetings and Program, Am.Soc.M.E., acted as chairman, showed the influence on the cost of living of the use of costly methods of handling materials in the factory and at the terminal points. In speaking of the transportation problem Mr. Wright, in illustrating the economy resulting from handling goods by machinery, pointed to the fact that the shipper and the consumer have the cars 2.6 times as long as the railroad actually requires for hauling them. If mechanical means were provided to supplement the human factor and increase the average output, he observed, it would be possible to do this work much more quickly, and thus relieve the congestion at the terminals and keep the equipment moving for a proportionately greater time each day.

J. H. Leonard contrasted the perfection of the American railway machine with the "disgraceful" situation in the terminals. The roadbeds are the very best, the tracks are the fullest fruits of metallurgical science, bridges are substantial, rolling stock and motive power are the last words in design and construction, freight trains move expeditiously between points; but there perfection comes to an end. At the terminals trouble and expense begin, congestion quickly follows, with the result that terminal handling costs far exceed the cost of movement. Mr. Leonard saw no relief in sight with the recent announcement by the railroads that they propose spending nearly all of the enormous sums to come from the rate advances in the purchase of freight cars and locomotives. New cars, he added, would mean nothing more than floating storehouses, for the terminals could not handle the freight that would come to them. The solution of the problem, according to Mr. Leonard, must be worked out with the coöperation of almost every branch of engineering, for it is a case of specific adaptations to specific requirements which a survey and study alone can properly determine.

Two other papers were presented at the materials handling section, namely, Bringing the Food to the Table, by Rumsey W. Scott; and Cost Cutting with Conveyors, by W. T. Spivey. Of mechanical engineering interest were also the following papers which were presented at the other sessions: Recoverance: A Physical Property in Material and Its Importance, by Robert G. Guthrie; A Classification of Sheet-Steel Enamels, by R. R. Danielson; and Refractories, by Homer F. Staley.

HEAT-INSULATING VALUE OF CORK AND LITH BOARD

(Continued from page 626)

reading in Fig. 3. This key represents a section through the test box and shows the points at which temperatures were measured, together with the reference number to the thermometer.

The principal temperature readings obtained in the tests of Series 1 and 2 are shown graphically in Figs. 3 and 4, the results being plotted on logarithmic coördinates. Fig. 5 represents the final results of the conductivity and heat transmission of the two materials tested.

Conclusions

The results of these tests are of special interest because of the low value of the external temperature, the average for all tests being approximately 10 deg. fahr. The mean temperature of the materials tested was approximately 40 deg. fahr.

These tests indicate that the heat-insulating property of cork board is slightly better than that of lith board. For the samples tested the lith board has a conductivity approximately 5 per cent greater than that of cork board.

The conductivity and heat transmission of the materials tested increases with the temperature. The change is small, however, between the temperature limits employed in this investigation.

Any discrepancies in the results are more likely to occur at the lower heat inputs with their consequent small temperature differences.

Small differences in temperature materially reduce the heat flow. Under such conditions the rate of change in the adjustment of temperatures is likewise small and it is easily possible to assume conditions constant before they have properly adjusted themselves. This may result in serious error.

The conductivities of the materials as determined in this investigation agree fairly closely with those obtained by other investigators. The United States Bureau of Standards, for example, gives the following values for the conductivity of cork board:

Conductivity, B.t.u. per in. per deg. per sq. ft. per 24 hr.	7.4
Density of material, lb. per cu. ft.	11.3
Mean temperature of material, deg. fahr. (25 deg. cent.)	77.0

NEW FORD PLANT AT RIVER ROUGE

(Continued from page 641)

steam headers, both connections being on the same side of the boiler. From the saturated-steam headers the steam passes through the elements and is returned to the 12-in. superheated-steam header and discharged at the side opposite that at which it enters the saturated headers, thereby avoiding any possibility of short-circuiting and at the same time attaining correct steam distribution through all the elements.

Probably the most important and unique feature of the superheater is the location of the units. These are placed in the first pass of the boiler, protected by several rows of boiler tubes. The space for the location of the superheater units was selected in order to protect the elements from too high a temperature and at the same time provide for maintaining high superheat without overheating.

A feature in the unit or element design is the use of the forged return bend. These return bends are made on the ends of the units from the metal of the pipe itself by a special mechanical forging process without the use of electric or acetylene welding. The distribution of the metal in the return bends is such that there is an increased section in the bend at the point where the hottest gases impinge. The use of the forged return bend in the unit construction results in a continuous pipe, the bend itself being actually stronger than the body of the pipe. It also affords a sharp return without adding excessive pipe friction and facilitates the convenient and advantageous location of the superheater units.

Pulverized-Fuel Equipment

The boilers will be fired with a combination of pulverized coal and blast-furnace gas. A pulverizing plant of suitable capacity, using air separation mills, is being installed, and coal will be conveyed to the boilers from this plant by a series of screw conveyors.

Each boiler will be equipped with 12 "Lopulco" feeders and 4 "Lopulco" triplex burners, firing the coal vertically from the top. They will also be equipped with 8 gas burners for the purpose of injecting blast-furnace gas horizontally through the side, the gas flame and the pulverized-fuel flame so uniting at the proper point in the combustion chamber as to very greatly improve and increase the efficiency of the blast-furnace gas.

The possible capacity ratings when burning powdered coal will be extremely high, as the firing equipment is of such a capacity as to burn completely sufficient coal to produce 400 per cent rating continuously. It is probable that a high percentage of efficiency will be maintained throughout the whole cycle of operation, as the efficiency curve when pulverized fuel is properly handled is very flat from 50 per cent to 400 per cent of normal rating. The day operation of the boilers will be around 250 per cent of rated capacity.

A national convention of Italian engineers was held at Naples on May 20–25 under the auspices of the National Association of Italian Engineers. Among the topics discussed was that of Civic Activities of the Engineer.

There were present at the convention numerous government officials, delegations of Italian engineering associations and representative engineers from all sections of Italy.

The tenor of the addresses indicated a determination of the Italian engineers to assume "a leading position" in "technical and political" questions in Italy. It was emphasized by one of the principal speakers that to the engineers, who are by profession dedicated to the cultivation of the exact sciences, belongs an exalted position in all matters related to the general progress of humanity.

An incident of the convention was the reading by the chairman of a letter from the Federation of Italian Engineers, in which this organization announced that it had agreed voluntarily to its own dissolution, leaving the way clear for the National Association of Italian Engineers to engage in the furthering of civic activities of engineers in national questions.

Resolutions were adopted in which the desirability and importance of engineers taking an active interest in civic questions of national character were upheld, and reforms were suggested in regard to the policy followed by the Department of Public Works of Italy.

LIBRARY NOTES AND BOOK REVIEWS

The New Fall Books

By Harrison W. Craver, Director Engineering Societies' Library

PUBLISHING is to a considerable extent a seasonal business, the busy period beginning with the first days of fall and extending through the months of winter. The present time is a favorable one, therefore, for surveying the probable literary output, as most of the important works that will appear have been arranged for.

In order to ascertain what may be expected, a number of the more important publishers were asked to indicate those of their proposed publications which they expected would appeal to the engineer, and a study of their replies was made.

One is immediately struck, upon looking over the list, with the general belief among publishers and authors that the questions upon which the public wishes enlightenment at present are economic rather than technological. Problems of management, of labor, of accounting and of selling account for a considerable part of the season's output of books. This is what would naturally be expected; the business field has been entirely neglected until recent times and the present demand for business books is extensive and increasing. Conditions prevailing since the war have brought matters of management to the front in a decisive manner.

Among general books for the executive we notice, first, Howard T. Wright's Organization as Applied to Industrial Problems (J. B. Lippincott Company). This, according to the publisher, is a concise general summary of the principles of organization, based on a varied business experience of twenty-five years. Other books are devoted to more specific problems, as Carle M. Bigelow's Management in the Woodworking Industry (*Industrial Management*); Walter N. Polakov's Mastering Power Production (*Industrial Management*), which discusses power-plant operation; and C. U. Carpenter's Increasing Production: Decreasing Costs (*Industrial Management*), which treats of ways and means for utilizing labor, machinery and floor space most efficiently. Two books intended primarily for college use may also be of interest, Horace Secrist's Readings and Problems in Statistical Methods (Macmillan) and O. B. Goldman's Financial Engineering (John Wiley and Sons). The first of these is intended to show students and executives, in a practical manner, how statistics may be used. The second is described as a textbook for consulting, managing and designing engineers and for students.

Among new books on accounting appears one entitled Accounts in Theory and Practice, by Prof. E. A. Saliers, of Yale University (McGraw-Hill), which attempts to emphasize principles more definitely than is customarily done. The Ronald Press Company offers a five-volume work entitled Business Accounting, prepared by a number of experts under the editorial supervision of Harold D. Greeley, the volume on cost accounting being written by D. C. Eggleston. The same publisher has issued also a book entitled Cost Accounting, Its Principles and Practice, by Gould L. Harris, of New York University, and J. P. Jordan, Vice-President of the C. E. Knoeppel Company. This book attempts, in addition to explaining the technique of cost accounting, to show the uses of cost-account data by executives to secure current control of the industry. G. Charter Harrison's Cost Accounting to Aid Production (*Industrial Management*) is also intended to aid the operating department as well as the treasurer, and so discusses cost accounts from an engineering viewpoint.

Technical advertising sees its first textbook in Advertising the Technical Product, by C. A. Sloan, Advertising Manager for the Hyatt Roller Bearing Company and J. D. Mooney, of the General Motors Company (McGraw-Hill), a book which discusses the special problems involved in preparing and placing the advertising of mechanical devices and similar manufactures. The McGraw-Hill Book Company will publish also Essentials of Advertising, by F. L. Blanchard, Editor of *The Fourth Estate*.

Two books on banking appear, intended for the business man rather than the banker. Chester A. Phillips' Bank Credit (Macmillan) explains commercial credit and discusses in detail the analysis of mercantile credit, the interpretation of credit statements and the evaluation of the different items. It should assist the merchant by its explanation of the principles that the bank applies in analyzing his statement. W. H. Kniffen's The Business Man and His Bank (McGraw-Hill) is intended to make the business man familiar with the work of a bank and to show him what he may expect the bank to do for him.

Commerce is represented by two books. The Elements of Marketing, by P. T. Cherington (Macmillan), is based on the author's experience in teaching the subject at Harvard University and is an attempt to formulate the principles underlying the transfer of merchandise from producer to consumer under modern conditions. The Century Company begins a new series on foreign trade with Robert E. Annin's Ocean Shipping: Elements of Practical Steamship Operation, a book dealing with the fundamentals of ship management and operation. Another book in the series that should prove useful is Packing for Export, by H. R. Moody, who was in charge of the packing and shipping of Government supplies overseas during the war.

Labor and labor problems have led to several books treating various phases of the question. Personnel Administration, by Ordway Tead and H. C. Metcalf (McGraw-Hill), is a systematic discussion from the management viewpoint. Daniel Bloomfield has written Labor Maintenance (Ronald), describing how harmony may be maintained between the management and the workers and giving practical Illustrations of accomplishment. Nathan W. Shefferman's Employment Methods (Ronald) discusses the functions of the employment department and describes modern methods of selecting and assigning men to obtain a stable labor force. Roy W. Kelly's Training Industrial Workers (Ronald) presents suggestions to be followed by industrial firms in training employees. The Macmillan Company announces John A. Ryan's Social Reconstruction, and The Church and Labor, by John A. Ryan and Joseph Husslein. The former book, compiled from lectures at Fordham University, outlines a comprehensive program, including a minimum wage, collective bargaining, coöperative societies, health insurance and labor participation in management. The second is an authoritative statement of the attitude and teaching of the Roman Catholic Church in relation to labor and society. The same firm also announces Sigmund Mendelsohn's Labor's Crisis, a discussion of some phases of the problem from the employer's point of view, which recommends improvement of housing and modified profit sharing.

Turning from general administrative matters to those more technical, the mechanical engineer finds two additions to the steadily growing library of handbooks. The Marine Engineers' Handbook (McGraw-Hill), edited by Lieut.-Com. F. W. Sterling, U. S. N., is the first American work of the kind and will undoubtedly prove welcome. J. D. Hoffman's Handbook for Heating and Ventilating Engineers (McGraw-Hill) is not new, but appears in a thoroughly revised and modernized form. Welding has been a much-discussed operation in recent days, and three new books are listed: Practical Electric Welding (Spon), by H. B. Swift; Gas and Electric Welding (American Technical Society), by George W. Cravens; and Spot and Arc Welding (Lippincott), by H. A. Horner. Two books deal with lubrication: One, a rewritten and enlarged edition of John R. Battle's Lubricating Engineers' Handbook, is now entitled Lubrication and Industrial Oils, and forms the first volume of a Handbook of Industrial and Oil Engineering to be published by the J. B. Lippincott Company. The other book is by T. C. Thomsen and is entitled Practice of Lubrication (McGraw). Prof. Franklin DeR. Furman, of Stevens Institute of Technology, announces a work entitled Cams: Elementary and Advanced (Wiley). Elements of Engineering Thermodynamics (Wiley) is the joint work of Director James A. Moyer, of the Massachusetts Department of University Extension, Prof. James P. Calderwood, of the Kansas State Agricultural College,

and Audrey A. Potter, of Purdue University. For the automotive engineer, E. P. Dutton and Company offer the Theory and Practice of Aeroplane Design, by S. T. G. Andrews and S. F. Benson. John Wiley and Sons have a new edition of Pumping by Compressed Air, by E. C. Ivens.

For some unknown cause, the electrical engineer has little representation in the autumn lists. John Wiley and Sons announces Engineering Electricity, by Prof. Ralph G. Hudson, of Massachusetts Institute of Technology; and Principles of Radio Communication, by Prof. J. H. Morecroft, of Columbia University, Prof. A. Pinto, of Cooper Union, and W. A. Curry, of the New York Edison Company. The McGraw-Hill Book Company announces the third edition of Dr. C. P. Steinmetz's Transient Electric Phenomena. The Vacuum Tube, by Dr. A. J. Van der Bijl, and a Course in Electrical Engineering, by Prof. C. L. Dawes, of Harvard. Spon and Chamberlain present The Strowger Automatic Telephone Exchange, by Mordin, a work of English origin. The Century Company announces two books by M. Luckiesh, of the General Electric Company, treating the subject for non-technical readers. Lighting the Home offers advice on all domestic lighting problems, while Artificial Light: Its Influence on Civilization, is a history of the development of artificial light and its influence on human progress.

The mining engineer is offered various additions to his library. J. R. Finlay has prepared a new edition of his Cost of Mining (McGraw-Hill). Robert McGarraugh writes on Mine Records and Accounts (McGraw-Hill). Steam Shovel Mining (McGraw), by R. Marsh, Jr., is a practical review of methods. Flotation (Wiley), by T. C. Rickard, will be of interest to many. A book that should prove very useful to those who expect to travel or work in Russia is C. W. Purington's Vocabulary of Russian-English and English-Russian Mining Terms (Lippincott). This includes not only technical terms, but also those needed by the traveler and camper, legal and financial terms, and tables of weights. Political and Commercial Geology, and the World's Mineral Resources (McGraw-Hill) is the work of J. E. Spurr, Editor of the *Mining Journal*. The oil producer will find that subject treated in the Geology of Petroleum (McGraw-Hill), by Prof. W. H. Emmons, and in Field Methods in Petroleum Geology (McGraw-Hill) by Professor Cox, Dake and Muilenberg, of the Missouri School of Mines. Prof. W. A. Grabau has prepared the first volume of a Handbook of Salt Geology (McGraw-Hill), dealing with an important question which has hitherto escaped adequate treatment.

The construction engineer finds a new edition of Charles Evan Fowler's Ordinary Foundations (Wiley); Reinforced Concrete Construction (Spon), by Cantell; a Handbook of Building Construction (McGraw-Hill), by G. A. Hool and A. N. Johnson; and Concrete Work, a book to aid self-development of workers in concrete and for students in engineering (Wiley), by William K. Hatt, of Purdue University, and W. C. Voss, of Wentworth Institute. Engineers interested in agricultural matters may find assistance in George Thomas' Development of Institutions Under Irrigation (Macmillan), a history of irrigation in Utah. Studies in French Forestry (Wiley), by Theodore S. Woolsey, Jr., the Executive Member of the Interallied War Timber Committee, 1917–1919, will interest foresters, and C. W. Murphy's Drainage Engineering, (McGraw-Hill), will be welcome. Prof. T. R. Agg, of Iowa State College, is the author of American Rural Highways (McGraw-Hill). A revised edition of the Manual for Testing Materials (McGraw-Hill), by W. K. Hatt and H. H. Scofield, is announced.

The analytical chemist will look for Dr. A. D. Little's Technical Methods of Analysis (McGraw-Hill), the Technical Examination of Crude Petroleum (McGraw-Hill), by W. A. Hamor, and the new edition of Rapid Methods for the Chemical Analysis of Special Steels, Steel-Making Alloys, Their Ores and Graphites (Wiley), by Charles M. Johnson.

The new edition of A Dictionary of Chemical Solubilities—Inorganic (Macmillan), by Arthur A. Comey and Dorothy A. Hahn, will be received with appreciation, as it has been out of print for several years and also needed revision and extension. The most noticeable general works are another volume—Volume 9, Part 1—of J. Newton Friend's valuable Textbook of Inorganic Chemistry (Lippincott), probably the best general English text for reference use, and a thoroughly revised edition of Holleman's Textbook of Organic Chemistry (Wiley), edited by A. Jamieson Walker.

Special books will appear on the chemistry of various industries. C. F. Cross and E. J. Bevan have prepared a new edition of their well-known Textbook of Paper Making (Spon), Edwin Sutermeister, chemist to the D. Warren Company Paper Mills, has written the Chemistry of Pulp and Paper Making (Wiley), and Spon and Chamberlain offer The Recovery and Re-manufacture of Waste Paper, by Strachan. J. Merritt Matthews writes on the Application of Dyestuffs to Textiles, Paper, Leather and Other Materials (Wiley). Alvah H. Sabin has rewritten and enlarged Red-Lead, and How to Use it in Paint (Wiley). Dr. W. B. Bancroft's Applied Colloid Chemistry (McGraw-Hill) is on a subject whose importance is only beginning to be realized. S. L. Hoyt has written Part 2 of his Metallography (McGraw-Hill), treating of the metals and common alloys, and Bonewski's Studies in Alloys is announced by the J. B. Lippincott Company. The Century Company is publishing The New Stone Age, by H. E. Howe, of the National Research Council, a non-technical account of the uses of cement and concrete, intended for the "general" reader.

The same reader is the object of The New World of Science: Its Development During the War (Century), a collection of essays on the scientific advances made in surgery, communication and other arts, edited by Dr. Robert M. Yerkes, of the National Research Council. Another historical work is Hoogaard's Modern History of Warships (Spon).

The Century Company announces two biographies of engineers. Rose W. Lane and Charles K. Field have prepared The Making of Herbert Hoover: a Biography, in which special attention is given to his early life; and W. Vaughan has written The Life and Work of Sir William Van Horne, the story of the builder of the Canadian Pacific Railway.

Advertising the Technical Product. By Clifford Alexander Sloan and James David Mooney. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 6 × 9 in., 365 pp., illus., $5.

This book, the work of two men experienced in advertising technical products, is a discussion of the more important factors of the problem. The subjects discussed are the economic elements of such advertising, the instruments available for it, the preparation of technical advertisements and advertising organizations. An interesting and varied collection of actual advertisements, with critical comments, and a brief bibliography are included in the book.

Hydraulic Tables. The Elements of Gagings and the Friction of Water Flowing in Pipes, Aqueducts, Sewers, etc.; Flow of Water over Sharp-edged and Irregular Weirs and the Quantity Discharged. By Gardner S. Williams and Allen Hazen. Third edition, revised. John Wiley and Sons Inc., New York, 1920. Cloth, 6 × 9 in., 115 pp., illus., plates, tables, $2.

The third edition of these well-known tables has been carefully corrected and revised in minor points, and a new chapter has been added, in which the additional data that have accumulated during the fifteen years since these tables first appeared are examined to ascertain whether changes or adjustments in the formula are needed.

Wings of War. An Account of the Important Contribution of the United States to Aircraft Invention, Engineering, Development and Production During the World War. By Theodore Macfarlane Knappen, with an introduction by Rear-Admiral D. W. Taylor. G. P. Putnam's Sons, New York, 1920. Cloth, 6 × 8 in., 289 pp., plates, $2.50.

The story of the United States army-aircraft production program is essentially one of confident hopes, bitter disappointments, failures and successes such as inevitably attend the creation from nothing of an immense industrial organization. Until now, the history of this undertaking is chiefly found in the voluminous reports of investigating committees, which overemphasize the failures and undervalue the successes. The present book is an attempt to supply a less one-sided account of the army air effort, one which will give a readable report of the problem, the methods used for its solution and the net results obtained.